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TULIP EELWORM SURVEYS IN 1955

Summary by

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The tulip race of Stem and Bulb eelworm, *Ditylenchus dipsaci* (Kühn) was first recorded in tulips in the Holland Division of Lincolnshire in 1943 by T. Goodey (*J. Helminth.*, 1943, **21**, 30–2). Since then it has spread quickly throughout that important bulb-growing district and has also been found in some of the neighbouring counties. For several years it has been the cause of much concern to the growers and to the local advisory officers. Following discussions between representatives of the Ministry of Agriculture, Fisheries and Food and of the bulb industry, it was decided to carry out surveys to obtain more information on the distribution of the pest. The objects of this work were to determine, firstly, what proportion of tulip stocks was infested in the Holland Division of Lincolnshire ; secondly, whether there had already been a significant spread to other parts of the country ; and, thirdly, whether infested bulbs were being imported from abroad.

To provide information on eelworm incidence within the Holland Division, a survey of tulip stocks was carried out during April and May 1955. Too little was known to plan a detailed survey which would give quantitative information on intensity of infestation or on degree of damage, but it was considered that an extensive survey, based on the presence or absence of infestation in each stock, would probably provide the necessary data on which to base recommendations for future action. More detailed observations were made on a few farms to obtain information which would help in future planning of sampling techniques.

To estimate the extent of spread outside Lincolnshire, advisory entomologists were asked to co-operate in a country-wide reconnaissance survey, which involved examining as many tulip stocks as possible (both forced and outdoor) grown in nurseries, public parks and gardens in all parts of the country. This report summarizes the results of the work.

EXTENSIVE SURVEY IN HOLLAND, LINCS

A list of the farmers in the Holland Division who grew tulips in 1954 was supplied by Mr. J. O. Page, County Horticultural Officer (N.A.A.S.) for Holland, Lincs, and checked by the Ministry's Statistical Branch at Lytham St. Annes against the June 1954 Agricultural Returns for the area. The final list was discussed with Mr. B. M. Church of the Rothamsted Statistical Department, and it was agreed that the labour force available for the survey would enable a large sample to be taken. Sample frequencies of one in six for growers of one acre or less, and one in three for growers of more than one acre, were selected as likely to give good estimates of eelworm infestation. The final sample list included 149 growers with an estimated acreage of 452¼, out of a possible 636 growers with a total acreage of 1,674½. In practice, 418¼ acres (134 growers) were examined, and the results set out in this report therefore refer to a sample of 25 per cent of the tulip acreage farmed by 21 per cent of the growers.

The object of the survey was to record the presence or absence of Tulip eelworm in every stock on each farm on the sample list. Each stock was walked in turn under the direction of a team leader. Inspection was done as far as possible

at flowering time, although this was not possible with all varieties, even though two or more visits were made to most of the farms, because of differences in flowering time between varieties. As soon as an eelworm-infested plant was seen, the stock was noted as affected and the observer moved on to the next. The following information was recorded on field forms :

For each farm : Number of fields growing daffodils and tulips in 1955, and total outdoor acreage of these bulbs.

For each field : Acreage of tulips, and year when the part of the field last grew tulips and/or daffodils.

For each stock : Name of variety, approximate number of bulbs, origin of stock, stage of development of flowers at time of inspection, and presence or absence of eelworm.

The survey was carried out by four three-man teams and one two-man team, working for ten days. Four of the team leaders worked approximately five days each in the following week, the survey taking about 160 man-days to complete.

In the Holland Division, tulips are grown either in beds at a spacing of about eight inches, or on ridges with about 28 inches between rows. The latter system is used mainly in the eastern part of the area. Eighty-three acres of ridged bulbs, at an average density of 100,000 bulbs per acre, and 335¼ acres of bedded bulbs, at an average density of 145,000 per acre, were inspected. The sampled areas included 2,153 stocks of 361 varieties, and the relevant data are shown in Table 1.

TABLE 1

TULIP STOCKS INSPECTED IN RELATION TO VARIETIES GROWN AND EELWORM INFESTATION

Number of Stocks Inspected	Number of Varieties in these Stocks	Number of Stocks with Eelworm Absent	Number of Stocks with Eelworm Present	Percentage of Stocks Infested
20 or more	26	1,063	167	13·6
10–19	16	190	22	10·4
Less than 10	319	652	59	8·3
Total	361	1,905	248	11·5

As might be expected, the percentage of infested stocks is higher in the more popular varieties than in those of which only a few stocks are maintained. It is likely that where single, or only a few, stocks of a variety are grown these will either be new varieties, or very old ones, of which only the best stocks have been kept.

The overall estimate of 11·5 per cent of stocks infested does not by itself shed much light on the problem. Therefore, four analyses have been carried out on the data in an attempt to clarify matters. Firstly, farmers were classified into small growers (one acre or less of tulips consisting, on average, of 11 stocks), medium growers (1·1–10 acres with an average of 18 stocks), and large growers (over 10 acres with an average of 44 stocks). Secondly, farms were grouped

TABLE 2

ACREAGE OF TULIPS GROWN IN RELATION TO THE GEOGRAPHICAL DISTRIBUTION OF INFESTATION

Acreage of Tulips Grown in 1955	Number of Stocks Clean	Number of Stocks Infested	Percentage of Total Infested	Percentage of Total Stocks Infested, Grouped Geographically N.W.	S.W.	N.E.	S.E.
Less than 1·1 ..	376	85	18·4	23·5	29·7	3·6	18·5
1·1–10	1,126	160	12·5	18·9	16·5	8·9	0·7
Over 10	403	3	0·7	2·7	—	—	1·6
Total	1,905	248	11·5	17·7	14·7	5·5	4·2

geographically into four approximately equal areas, with a similar number of growers in each area. Those, for example, west of the Greenwich meridian and north of a line from Spalding to Long Sutton were classed as " north-west ". The distribution of infested and healthy stocks within these categories is shown in Table 2.

Evidently the percentage of infested stocks varies inversely as the acreage of tulips grown. Growers of less than 10 acres have a relatively high proportion of infested stocks, whereas the large growers, with more than 10 acres, have a negligible amount of eelworm. In addition, it seems clear that the medium-sized and small growers in the western part of the Division have more trouble with eelworm than those in the north-east and, so far as the medium-sized growers are concerned, in the south-east also. It is therefore of particular interest that the large, and presumably more efficient, growers also have more eelworm in the north-west than in the south-east of the Division.

The data for the third analysis have been tabulated in relation to past cropping with daffodils and tulips to see if there is any connection between recent bulb production and eelworm infestation. The relevant results are set out in Table 3.

TABLE 3

PERCENTAGE EELWORM INFESTATION IN RELATION TO PAST CROPPING WITH DAFFODILS AND TULIPS

Years since Land Previously Cropped with Eelworm Hosts		Acreage of Tulips Grown by Farmers in 1955 Under 1·1	1·1–10	Over 10	Number of Stocks Inspected
0–3 years	Percentage of total stocks grown ..	19	17	25	405
	Percentage infested	26	3	0	30
4–6 years	Percentage of total stocks grown ..	24	24	41	589
	Percentage infested	15	6	0	36
7–9 years	Percentage of total stocks grown ..	1	17	11	262
	Percentage infested	40	17	2	38
Over 9 years	Percentage of total stocks grown ..	5	7	3	128
	Percentage infested	12	17	0	19
Never before	Percentage of total stocks grown ..	49	29	20	682
	Percentage infested	14	17	1	95
Not known	Percentage of total stocks grown ..	2	6	0	87
	Percentage infested	33	32	0	28
Number of stocks inspected ..		480	1,275	398	2,153

It is of some interest that the small growers apparently produce 49 per cent of their tulips on land never before cropped with eelworm hosts, whereas the large men grow only 20 per cent of their bulbs on virgin land. It is possible that in this instance the information given to the survey teams may not be strictly correct. It is also worth noting that small growers using short rotations of two or three years have, on average, a quarter of their stocks infested with eelworm. Large growers tend to use a five- or six-year rotation, and have a very low infestation rate.

Finally, the data on varieties have been tabulated, and sufficient information is available for three of them to allow of a worthwhile comparison in relation to small and medium growers.

TABLE 4

VARIETY IN RELATION TO SIZE OF GROWER AND PERCENTAGE OF STOCKS INFESTED

Variety	Number of Diseased Stocks		Total Stocks Examined	Percentage of Stocks Infested
	Small Growers	Medium Growers		
Rose Copland ..	4	11	90	17
Zimmerman ..	4	6	45	22
Mixed	18	15	112	29

Other varieties of which many stocks were infested were : Van der Eerden (8 per cent) and Golden Harvest (6 per cent) amongst the small growers ; and Fantasy (21 per cent), William Copland (18 per cent), Mozart (14 per cent), Inglescombe Yellow (12 per cent) and Clara Butt (11 per cent) amongst the medium growers.

DETAILED OBSERVATIONS IN HOLLAND, LINCS

The detailed observations were designed to give further information on sampling within and between tulip stocks and fields, and observations were restricted to stocks with a high proportion of infested bulbs. Five stocks were eventually selected, of the varieties William Copland, Farncombe Saunders, Victoria d'Oliviera, Krelage's Triumph, and Rynland. Counts were made, at random, of 100-bulb lengths of row in two adjacent rows, and the number of plants showing eelworm symptoms was recorded. Five random samples were taken in each stock at each visit by each of the two observers. The growth stage of the bulbs varied from green-bud to colouring to flowering, and the weather was recorded as fine, windy, or wet.

An analysis of the results showed that there was no difference in the ability of two observers to assess symptoms in the same stock at the same time in the same field ; there were detectable differences in infestation levels between varieties, a result which may have been due to variations within stocks between varieties. Significant differences were noticed between the same stocks sampled under different weather conditions, and it is clear that in wet or windy weather eelworm symptoms become increasingly hard to detect. At the green-bud stage it is very difficult to recognize symptoms, and analysis has shown real diversity in apparent infestation levels at different growth stages.

Unfortunately, it was not possible to find suitable stocks of the same variety growing in single fields, so little information has been obtained on the patterns of eelworm infestation within individual stocks.

SUMMARY FOR HOLLAND, LINCS

Taken altogether, the results indicate that growth stage and weather greatly influence the ease with which Tulip eelworm symptoms can be detected in the field ; that approximately 11·5 per cent of the stocks grown in the Holland Division of Lincolnshire in 1955 were infested with eelworm ; that growers who raise more than 10 acres of tulips annually are substantially free from infestation ; that approximately 19 per cent of the stocks raised by growers of an acre or less are infested ; that there is apparently an infestation gradient in which the north-western sector of the Holland Division is more seriously affected by eelworm than the eastern sectors ; and that the more commonly grown varieties tend to be affected to a greater extent than those which are less commonly, or rarely, grown.

Tulip Eelworm Surveys

National Reconnaissance Survey

Observers in the national survey were asked to record on a simple form the name and address of the grower or authority, the nature of crop (whether forced, public park, etc.), the varieties of tulips, the quantity grown, the source of the bulbs (particularly whether English or Dutch), and the presence or absence of eelworm. No attempt was made to assess the degree of infestation in diseased stocks, anything from a single infested plant upwards being sufficient to class a stock as " infested ". In no sense was this a random survey, as was that in Lincolnshire.

The results for both forced and outdoor bulbs are summarized in Table 5. Stocks classed as Dutch do not include all those of Dutch origin but only those imported before the last planting—that is, those not previously grown in this country. Stocks classed as English comprise those brought in from Lincolnshire and other areas and those which were the grower's own stock—that is, those that had been grown on the nursery at least once before the present planting. The latter category included a few stocks of Dutch origin. Stocks of " unknown origin " are those where the source of the bulbs had not been recorded by the observers.

Table 5

Incidence of Infested Stocks

	English		Dutch		Unknown Origin	
	Total Stocks Inspected	Stocks Infested	Total Stocks Inspected	Stocks Infested	Total Stocks Inspected	Stocks Infested
Forced bulbs :						
Northumberland (Newcastle district)	10	0	0	0	0	0
Yorks and Lancs	28	0	135	0	21†	1
Lindsey and Kesteven ..	16	1	60	0	8	0
Flintshire and Denbigh ..	0	0	6	0	2	0
Cardigan, Carmarthen and Pembroke	0	0	8*	2	0	0
Glamorgan (Cardiff) ..	0	0	9	2	0	0
Eastern Counties	52	11	87	0	0	0
Kent and Sussex	0	0	63	0	0	0
Cornwall	6	0	7	0	0	0
Totals	112	12 (11%)	375	4 (1·1%)	31	1
Outdoor bulbs in nurseries :						
Durham	1	1	0	0	0	0
Lindsey and Kesteven ..	26	1	0	0	10	6
Flintshire and Denbigh ..	0	0	1	0	2	0
Norfolk, Suffolk and Peterborough	63	1	42	0	0	0
Devon and Cornwall ..	50	1	15	0	0	0
Totals	140	4	58	0	12	6
Outdoor bulbs in parks and gardens :						
Durham	3	0	9	0	3	0
Glamorgan and Monmouth (Cardiff, Swansea and Newport)	5	0	27	0	0	0
Kent and Sussex	110	2	38	0	130‡	2
Devon	5	0	3	0	0	0
Totals	123	2	77	0	133	2

* Nurseries. † Including 2 Irish, not infested. ‡ Manchester wholesaler.

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The figures for the Eastern Counties in Table 5 represent reports from Bedfordshire, Cambridgeshire, Essex, Hertfordshire, Huntingdonshire, Norfolk, Suffolk and the Soke of Peterborough. The total figures in parks and gardens are made up mainly from records from Kent and Sussex, where more tulips in public parks were examined than in any other counties. More infestations were found in forced bulbs than in those grown outdoors. Very little eelworm was seen in tulips grown in public parks and gardens, there being only 1·6 per cent of infested English stocks and 1·5 per cent of stocks of unknown origin.

The incidence of eelworm in relation to the origin of all the stocks inspected, both forced and outdoor, was as follows :

	Total Stocks Inspected	Stocks Infested	Percentage Infested
English	375	18	4·8
Dutch	510	4	0·8
Unknown origin	176	9	5·1
	1,061	31	2·9

Most of the infestations were in English bulbs. Eelworm was only found in four forced stocks known to be of Dutch origin. The possibility cannot be excluded that these became infested after planting, and there is no conclusive evidence from the survey or from any other source that Dutch bulbs are a source of infestation.

The infestation in different parts of the country, bringing in figures from the extensive survey in Holland for purposes of comparison, can be summarized thus :

	Total Stocks Inspected	Stocks Infested	Percentage Infested
Holland, Lincs	2,153	248	11·5
Lindsey, Kesteven and the Eastern counties ..	364	20	5·5
Rest of country	697	11	1·6

The incidence of Tulip eelworm, as would be expected, is relatively higher in the Eastern and East Midland counties adjoining the Holland Division of Lincolnshire than in the remainder of the country, which appears to be relatively free from the trouble. It seems likely that eelworm is spread much more in bulbs from bulb auctions than in bulbs bought direct from nurseries and suppliers ; eight stocks were infested out of 39 bought at bulb auctions (20 per cent), and five stocks were infested out of 144 originating from the Holland Division and Peterborough district (3·5 per cent), excluding those obtained from an auction.

SCOTLAND

Through the co-operation of the Department of Agriculture for Scotland, forced and outdoor stocks in seven different nurseries in Scotland were examined. Eelworm was confirmed in one stock only of forced bulbs, variety Rose Copland, originating from Peterborough. About 0·04 per cent of the stock was infested.

Thanks are due to Mr. A. H. Strickland and Mr. F. H. Jacob, who both assisted in planning the surveys, and to the former for his help in collating the results. The Plant Pathology Laboratory is also greatly indebted to all the N.A.A.S. officers who took part.

POTATO BLIGHT FORECASTING BY 90 PER CENT HUMIDITY CRITERIA

by L. P. SMITH

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Experience during the last six years, as described in previous articles in this JOURNAL (Large, 1953, 1956), has shown that outbreaks of Potato Blight on maincrops in England and Wales can be forecast to an acceptable degree of accuracy by the use of macro-climate data. The system by which this is done, based fundamentally on the Beaumont criteria, with an operations-chart method of interpretation, has given correct indications for most of the important potato-growing regions each year, but it cannot be said to be perfect. The warnings of *individual* stations have often been deficient, even for their immediate locality, and late outbreaks, especially in the drier seasons, have occurred in some districts without the antecedent warning periods that would be expected.

An analysis of the station performance as shown by the outbreak maps for 1950–1954 (Large, *loc. cit.*), shows that 43 out of a total of 220 forecasts from individual stations were not valid for their respective zones. Because of the method of consideration which searches for " flushes " and not individual warnings, these " failures " did not adversely affect the general decisions made on the basis of the meteorological evidence, but any improvement in the criteria which would reduce their number would obviously be beneficial.

Detailed examination of the weather data showed that it was in the humidity criterion that the apparent breakdowns occurred. The word " apparent " is used deliberately because it must always be remembered that a very big assumption is made when the observations taken in a Stevenson screen at an airfield are thought to be directly applicable to conditions in a field of potatoes many miles away. Such breakdowns often, but not invariably, occurred at stations which were situated on the lee of hill masses ; the humidities in such areas are often lower than might be expected from the general weather of the country.

The Beaumont criteria specify a minimum relative humidity below which the air should not fall—namely, 75 per cent. Instead of considering the avoidance of the lower humidities, it seemed promising to examine the duration of high humidities, such as those of 90 per cent or more. Such examination suggested that reasonable criteria would be provided by two consecutive days each with :

(*a*) Minimum temperatures 50°F or above (as in the Beaumont rule).

(*b*) Duration of humidity of 90 per cent or above : at least 11 hours.

A " near miss " would be two days of 10 hours of such high humidity at normal stations, or 8 hours at those stations in the lee of hills, such as Speke, Shawbury, Finningley and Dishforth.

Figs. 1 and 2 illustrate the correspondences between these " 90 per cent " periods and the Beaumont periods for four of the principal regions, in (Fig. 1) a dry season when blight outbreaks were late (1952), and (Fig. 2) in a bad blight year (1953). It will be seen that there was often a close correspondence between the Beaumont and the 90 per cent periods, but that the latter frequently filled in the picture, and indicated the occurrence of favourable conditions at a time appropriate for the outbreak, where the Beaumont criteria failed. This was particularly evident in the case of the August outbreaks in 1952.

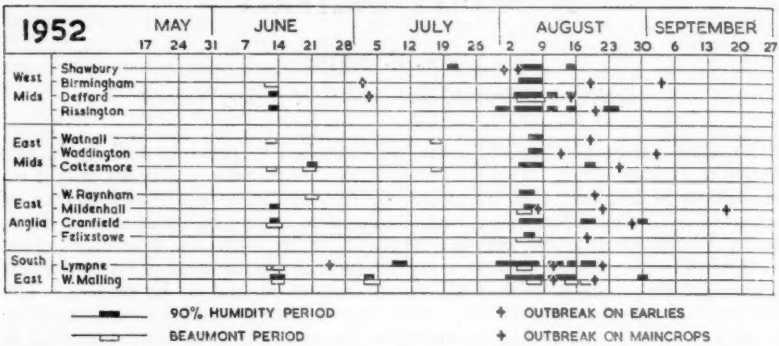

Fig. 1. Part of the comparative chart showing " 90 per cent " and Beaumont periods in relation to August outbreaks in four regions in 1952.

Comparisons for all the stations, and for all the years 1950 to 1954, showed that 29 out of the 43 " failures " by the Beaumont system would have been replaced by valid forecasts had the 90 per cent criteria been used, but that then nine of the warnings valid by the Beaumont system would have become failures, giving a net gain of twenty valid warnings. Thus the proportion of failures would have been reduced from about 20 to about 10 per cent.

Such an assessment is, however, rather academic, as it is the occurrence of regional flushes of warning periods that is important in our method of working and not individual station performance. It is of more interest to review what regional forecasts could have been given in each of the years had the 90 per cent criterion been substituted for that of Beaumont in the method of working that we have now developed.

For this purpose, the stations that have so far been arranged under headings of N.A.A.S. Provinces in the published operations charts, are here grouped more closely according to climatic similarities, thus :

North-East	..	bounded by the Humber and the Pennines
North-West	..	bounded by Cheshire and the Pennines
West Midlands	..	bounded by the Welsh Marches, Gloucester, Warwick and the Peak
East Midlands	..	bounded by Warwick to the Wash
East Anglia	..	bounded by Warwick to the Thames
South-East	..	Kent, east Surrey and east Sussex
South-West	..	Devon and Cornwall
Southern ..	..	all south of the line Gloucester—Warwick—London, excluding the S.E. and S.W.
North Wales		
South Wales		

There is only one station (Valley) in North Wales, but in all the other districts search could be made for flushes of warnings, and their potency could be differentiated by the use of the adjectives "weak" or "strong", according to the number of stations at which the warning periods occurred. The results of this review are summarized in Table 1. Following the practice in the operation of the existing scheme, flushes of warnings occurring in June are omitted as irrelevant, except in the South-West, Wales, and in certain exceptional circumstances elsewhere. The table itself provides further justification for this decision. The range of outbreak dates for each district is taken from the Beaumont operations charts already mentioned.

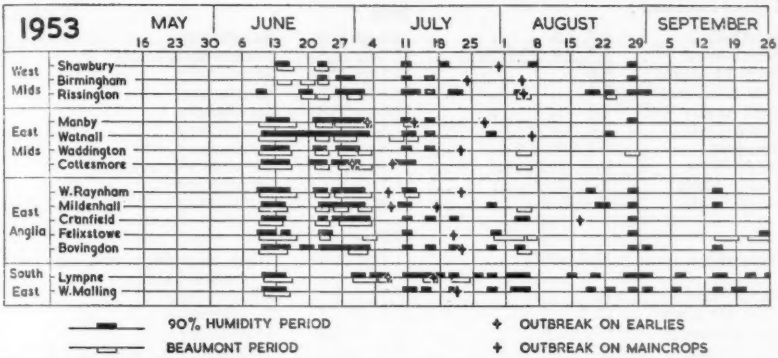

Fig. 2. Part of the comparative chart showing " 90 per cent " and Beaumont periods in relation to July outbreaks in four regions in 1953.

Table 1 shows that over the five years, forecasting by flushes of 90 per cent humidity periods would have been quite satisfactory about 7 times out of 10 and that main outbreaks would have been adequately predicted 8 times out of 10. The summary shows up the interesting point that sporadic warnings were almost always followed by sporadic outbreaks. Only once in 10 would the system have given a really poor result, and even so, it would not have been in the main potato-growing areas. Flushes occurring in neighbouring regions would also have been taken into account in the actual operation of the system, and this would have tended still further to reduce errors.

TABLE 1

REVIEW OF CORRESPONDENCE BETWEEN WARNING FLUSHES BY 90 PER CENT HUMIDITY CRITERIA AND BLIGHT OUTBREAKS, ENGLAND AND WALES, 1950–54

(Dates of strong flushes are shown in ordinary type, weak flushes in *italics*.)

Region	*Warning Flushes*	*Blight Outbreaks*	*Comment*
	1950		
North-East ..	*23.7, 2.8*	4.8 to 17.8	Weak warnings and sporadic outbreaks
North-West ..	22.7	31.7 to 2.8	Satisfactory
West Midlands ..	*6.7, 23.7*	17.7 to 1.8	Weak warnings and sporadic outbreaks
East Midlands ..	5.7, *19.7*	21.7 to 9.8	Mainly satisfactory
East Anglia ..	5.7	11.7 to 20.7	Satisfactory
South-East ..	5.7, 15.7	19.7 to 24.7	Satisfactory
Southern ..	27.6, 4.7, 19.7 ..	6.7 to 31.7	Satisfactory for main outbreak (22·7)
South-West ..	20.6, 27.6, *6.7* ..	1.7 to 16.7	Satisfactory
South Wales ..	27.6	11.7 to 19.7	Satisfactory
North Wales ..	11.7, and later ..	27.7 ..	Satisfactory
	1951		
North-East ..	*23.7, 4.8*, 7.8 ..	26.8 to 11.9	Only strong flush significant
North-West ..	*8.8*	12.8 to 27.8	Passable
West Midlands ..	6.8	12.8 to 29.8	Satisfactory
East Midlands ..	*21.7*, 7.8	21.8 to 3.9	Satisfactory
East Anglia ..	7.8	17.8 to 4.9	Satisfactory
South-East ..	11.7, 23.7	1.8 to 15.8	Satisfactory
Southern ..	*10.7*, 5.8	5.8 to 21.8	Satisfactory in general
South-West ..	*29.6*, 7.7, 18.7 ..	20.7 to 8.8	Premature on the whole
South Wales ..	25.6 to 11.7	22.7 to 8.8	Not very satisfactory
North Wales ..	3.7, 7.7, 27.7 ..	5.8 to 14.8	Premature for maincrops

Table I continued :

	1952		
North-East	*1.8*, 8.8	14.8 to 27.8	Satisfactory
North-West	*1.7, 8.7, 22.7, 31.7*	11.7 to 19.8	Locally satisfactory
West Midlands	6.8	15.8 to 20.8	Satisfactory
East Midlands	8.8	13.8 to 25.8	Satisfactory
East Anglia	7.8	18.8 to 28.8	Satisfactory
South-East	3.8, 7.8., 13.8	11.8 to 21.8	Satisfactory
Southern	8.7, 1.8, *6.8*	11.8 to 25.8	Satisfactory
South-West	10.6, *22.6*, 10.7	23.6 to 17.7	Variable over area
South Wales	*26.6, 10.7*	14.7	Satisfactory
North Wales	25.6, 8.7	15.7	Satisfactory
	1953		
North-East	*12.7, 17.7*	31.7 to 16.9	Weak warnings and sporadic outbreaks
North-West	20.7	27.7 to 5.8	Satisfactory
West Midlands	12.7	24.7 to 5.8	Satisfactory
East Midlands	1.7, 12.7	8.7 to 6.8	Satisfactory
East Anglia	2.7, 12.7	7.7 to 23.7	Satisfactory for most of area
South-East	12.7	17.7 to 22.7	Satisfactory
Southern	6.7, 12.7, 22.7	16.7 to 5.8	Satisfactory
South-West	15.6, 20.6	19.6 to 1.7	Satisfactory
South Wales	Frequent warnings	15.7 to 23.7	Impossible to assess
North Wales	15.6, 20.6, 6.7	13.7	Poor
	1954		
North-East	*5.8*, 18.8	26.8 to 27.8	Satisfactory
North-West	*17.7*, 24.7	30.7 to 4.8	Satisfactory
West Midlands	*8.7*, 17.7, 24.7	25.7 to 5.8	Satisfactory for main outbreak
East Midlands	17.7, 24.7	30.7 to 13.8	Satisfactory
East Anglia	9.7, 17.7, 24.7, 2.8	30.7 to 12.8	Satisfactory
South-East	25.6, 9.7, 17.7	6.7 to 18.7	Earliest outbreaks might have been missed
Southern	9.7, 17.7	22.7 to 27.7	Satisfactory
South-West	16.6, 21.6, 25.6	28.6 to 13.7	Satisfactory
South Wales	16.6, 21.6, 1.7	5.7 to 14.7	Satisfactory
North Wales	16.6, 21.6	7.7	Satisfactory

Backcasts of this kind can never be of quite as much value as actual forecasting experience, but it does appear that over the five years, forecasting based on flushes of " 90 per cent " warnings would have been acceptable, and the system would have overcome some of the deficiencies in the application of the Beaumont method in difficult circumstances. The difference in effectiveness of the two systems, however, would appear to be small in practice, and there would be little point in altering an established system unless the benefits are likely to be considerable. Real advantages would be gained if the number of hours of high humidity (90 per cent or over) each and every day at all the stations were available to the investigators, for this would provide a very clear picture of all the weather significant for the development of the blight fungus. Such records, however, would be too numerous for advisory purposes, and too overburdening for the weather observer.

REGIONAL DIFFERENCES IN HUMIDITY CONDITIONS

In the course of the work over the five years, an analysis was made of the number of days at each of the participating weather stations when the number of hours with 90 per cent humidity or more in the screen exceeded 12, 15 and 18 hours respectively during the months of July and August. The total number of hours with such high humidity was also extracted. The figures are given in Table 2, and they may be of considerable value in explaining the marked differences in blight development observed in the localities of the different stations in the years of the survey.

TABLE 2

AVERAGE DURATION OF RELATIVE HUMIDITIES OF 90 PER CENT OR MORE OVER THE PERIOD JULY 1 TO AUGUST 31 FOR THE FIVE YEARS 1950–1954

Station	No. of Days with More than 12 Hours	15 Hours	18 Hours	Total No. of Hours
Speke	3·6	0·8	0·2	244
Finningley ..	6·5	3·1	0·5	278
Shawbury ..	6·4	3·2	0·6	347
Abingdon ..	6·8	3·0	0·8	391
Squires Gate ..	9·0	4·2	1·6	345
Manchester ..	8·8	4·2	1·6	437
Felixstowe ..	10·2	5·8	3·2	371
Farnborough ..	10·4	5·0	2·0	449
Dishforth ..	10·6	5·0	3·2	423
Cottesmore ..	11·4	5·8	1·4	441
West Raynham ..	11·4	6·0	2·0	465
Defford	11·4	6·6	2·6	497
Mildenhall ..	12·0	5·0	1·4	458
Exeter	12·0	6·0	2·8	508
Driffield	12·4	6·0	2·6	498
Birmingham ..	12·6	7·2	2·6	477
Tangmere ..	12·8	6·2	2·8	508
Waddington ..	13·6	7·8	3·7	459
Cranfield ..	13·6	5·8	3·2	494
Hurn	13·8	6·6	5·0	523
Watnall	16·0	8·0	3·6	528
Acklington ..	15·8	9·2	5·8	546
Silloth	20·0	9·8	4·6	540
Rissington ..	19·8	11·6	6·4	571
Lyneham ..	20·4	11·2	4·4	600
Bristol	21·2	12·0	5·6	584
Pembroke ..	21·4	11·6	6·8	556
Chivenor ..	22·0	11·2	6·4	614
Lympne	23·4	12·0	5·2	613
Boscombe Down	23·4	12·4	5·8	655
Plymouth ..	23·0	16·2	10·8	671
Valley	23·8	13·6	7·2	603
West Malling ..	25·2	12·4	5·0	638
St. Eval	25·6	16·4	9·2	638

The figures in Table 2 point very clearly to the relative absence of high humidities at Speke, Finningley, Shawbury and Abingdon ; and also to the frequency of high humidities not only in the South-West, but also in Kent and on Salisbury Plain. A word of caution must, however, be introduced ; these are humidity figures only, and no account has been taken of temperature, which is also a factor in " blight weather ". It must also be stressed that the figures deal with the artificial " screen " climate, and not crop climate. It may be noted, for example, that although screen humidities are low in Cheshire and the Welsh Marches, we are by no means certain that crop humidities are equally low in comparison with crop humidities elsewhere. There are bigger humidity variations in the lee of hills than have hitherto been realized, and this fact may be of considerable plant pathological importance (Smith, 1954).

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CORYNEBACTERIUM BETAE (SP. NOV.) THE CAUSAL ORGANISM OF SILVERING DISEASE OF RED BEET

by W. G. KEYWORTH AND J. SHEILA HOWELL

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Silvering disease of red beet, *Beta vulgaris* L., was first recorded in Britain in 1945 (Moore 1948) on a seed crop of the variety Cheltenham Green Top. Since that time it has occurred in many seed crops of this variety, causing the loss of up to 75 per cent of the plants on some farms. The disease has also been seen on the variety Detroit and has been experimentally induced on other beet varieties, including sugar beet, and on mangolds, but it is at present of economic importance only on the variety Cheltenham Green Top. Preliminary accounts of the disease have been published by Keyworth (1953) and Keyworth and Howell (1954 and 1955).

SYMPTOMS

Symptoms of the disease can be seen on plants at all stages of growth but they are much more apparent at certain times. For seed raising, the stock seed is sown thickly in rows in a seedbed in the open during August. The young plants (known as stecklings) are usually left in the seedbed until February–March, when they are planted out in their permanent positions. They start to " bolt " in May and the seed crop is harvested in September–October. The plants show the most obvious symptoms of the disease in the period May–August. One or more leaves on the plant become silvery in appearance, the silvering often being most apparent at first along the veins. The whole lamina is soon affected and the silvering appears on other leaves. Finally, the plant wilts and dies.

These are considered to be symptoms of systemic invasion and are typical of the disease in the maturing crop, but similar symptoms can be found on a small proportion of the young stecklings in the autumn. The disease is seedborne and 1–2 per cent of the stecklings may show infection from this source a few weeks after the seedbed is sown. Later on, silvered lesions, presumably arising from the spread of the disease from the seed infection foci, appear on nearby plants. The lesions consist of silvery spots and patches on the upper surfaces of the leaves. They have a roughened appearance and often crack open in the centre. The edges of the leaves may also be silvered and cracked. Systemic symptoms have been seen on plants grown for the root crop (sown in June and harvested in October), but the numbers of affected plants are usually very small and the disease is not of economic importance on the root crop.

ISOLATION OF A BACTERIUM

A bacterium was first isolated in the autumn of 1954 from silvered spots and edges on the leaves of young stecklings and also from the taproots of systemically affected stecklings. The silvered lesions on the leaves were cut out and washed in sterile water ; then teased out in sterile water which was streaked out on to Yeastrel-peptone agar (Dowson, 1949). Portions of taproot were sterilized by dipping them in alcohol and flaming, and then teased in water which was also streaked out on to similar agar plates. Almost pure bacterial cultures were obtained by these procedures from the leaves and the roots. The individual

colonies were very small, smooth and translucent. The bacteria were short, gram-positive rods and thus probably a species of *Corynebacterium*.

INOCULATION EXPERIMENTS

After sub-culturing on Yeastrel-glycerol agar, the bacteria were inoculated on to leaves and into roots. The leaves of young plants growing in the glasshouse were inoculated by rubbing their upper surfaces with a finger previously rubbed on to a culture or dipped in a thick bacterial suspension. In some instances, celite was first dusted on to the leaves, and in all cases the leaves were finally washed with a gentle stream of water.

Of sixty leaves inoculated in these various ways in one experiment, forty developed typical silvery lesions, sometimes discrete and sometimes coalescent. Re-isolations from the lesions yielded an organism similar in every respect to the inoculum. The methods were all equally effective but it was subsequently found that the most uniformly successful inoculations were obtained by rubbing with a finger which had been rubbed on a culture, the leaves having previously been dusted with celite. Two cultures, one derived from a leaf lesion and one from a taproot, gave similar results. One leaf out of thirty controls (rubbed without bacteria) showed infection.

To inoculate the roots a hole 1·5 cm deep and 7 mm wide was cut with a cork borer into the shoulders of each of 32 taproots (3–4 cm diameter). Into 16 of the holes was placed about 0·5 ml of sterile water ; into 8, a similar quantity of a thick suspension of a culture of bacteria isolated from a leaf ; and into the remaining 8, a suspension of a culture of bacteria isolated from an infected taproot. The holes were closed with plugs cut from another beetroot. Three weeks later (in February) veinal silvering was seen on 12 of the inoculated plants, and after a further week all of them showed this symptom. The 16 control plants remained healthy. The silvering symptoms became more intense and were identical with those seen in the field. The bacterium was re-isolated from the taproots of the affected plants.

Experiments, similar to those described above, have been made on many occasions and constitute the proof that the bacteria are the cause of the disease. Further experiments are in progress to determine the mode of natural infection and the distribution of the pathogen within the plant.

THE CAUSAL ORGANISM

The pathogen was compared with other plant pathogenic species of *Corynebacterium*. Although similar to *C. michiganense* in microscopic appearance and certain cultural characters, it differed from this species and from all other described plant pathogenic Corynebacteria in its colour on agar. Thus on Yeastrel-glucose and meat-infusion glucose yeast agars its colonies were pale yellow and transparent. On these media all the other species tested form yellow opaque growths. In several experiments the beet pathogen failed to infect tomato or potato stems. It is thus considered to be a hitherto undescribed species of *Corynebacterium*, for which the name *Corynebacterium betae* is proposed.

Technical Description

Corynebacterium betae sp. nov. is a short, gram-positive rod which is motile when freshly isolated (Craigie-tube test), and bears three peritrichous flagella (electron micrograph). It occurs as single cells (rarely in pairs) which measure 0·8 to 1·6μ × 0·3 to 0·5μ.

On Yeastrel-glucose and on meat-infusion glucose yeast agar the colonies are circular, convex, pale yellow and transparent, thus distinguishing the organism from other species of Corynebacteria pathogenic to plants, which form yellow opaque colonies. On steamed potato and on yeast-glucose $CaCO_3$ agar the growth is mustard yellow and " runny ". Gelatin is slowly liquified, and in litmus milk a soft buff coloured curd is slowly digested and the litmus is reduced.

There is some diastatic action and nitrate is not reduced to nitrite. The optimum temperature for growth is 22·5°C to 25°C. Slight growth occurs at 37°C and the thermal death point (broth cultures) is 55°C (10 minutes).

Acid but no gas is formed from glucose, lactose, maltose, sucrose, glycerol and salicin in a peptone-free synthetic medium containing 0·05 per cent yeast extract (brom-thymol-blue indicator).

Cultures of the organism have been deposited in the National Type Culture Collection of Plant Pathogenic Bacteria, Ministry of Agriculture, Fisheries and Food, Plant Pathology Laboratory, Milton Road, Harpenden.

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A METHOD OF ESTIMATING CYST CONTENTS WITH MIXED BATCHES OF *HETERODERA* SPP.

by J. H. FIDLER

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Reid (1955) has described a method of estimating the eggs and larvae in the cysts of the Potato Root eelworm, *Heterodera rostochiensis* Woll., in which the cysts are crushed with a small roller and then mixed with an electric stirrer. She found a mean gain of 21 per cent over the older methods. Bijloo (1954) opened the cysts with a Hagedorn needle and used a homogenizer to break up the clumps of eggs. Unfortunately, when examining field samples of " lemon-shaped " cysts for advisory purposes, pure populations of a single *Heterodera* species are seldom encountered and each cyst has therefore to be

examined individually and identified before it can be added to the batch for egg or larval estimation. In view of this, a modified method, which I have evolved, has been in use at this centre for some time and has proved both accurate and reasonably quick.

Cysts picked out from the dried float, obtained with a Fenwick apparatus, are soaked in about ½ ml of water for one or two days in a solid watch glass. After removing most of the water with a fine pipette, a single cyst is transferred to a single drop of water placed about ½ inch from the end of a 3 × 1 inch Perspex slide. The cyst is then sliced open with a Hagedorn needle (Reid 1952), the cut being made transversely across the cyst near the equator below the vulva (Cooper 1955). The eggs and larvae are then removed with the needle, taking care not to damage the " bullae " below the vulva.

The cyst being examined must at this stage be identified by examination of the vulva or by larval measurement. In the former case, the half-cyst can be held down with a needle to obtain a side or end view of the vulva according to requirements (Cooper, *loc. cit.*). When larval measurements are required, it will be unnecessary to use a cover slip if enough water is added to get a flat surface. If it is decided that the cyst is of the species being counted, the end of the slide is dipped into a 50 ml beaker containing about 20–30 ml of water. When the slide is removed, practically no eggs will adhere to it if the water is drained off into the beaker. On blotting the under side of the slide on filter paper it will be ready to receive the next cyst for identification.

The number of cysts added to the water in the beaker is noted and the contents are transferred to an 8 × 1½ inch hard glass boiling tube. They are then mixed on an electric laboratory stirrer. I use an attachment shown to me by Mr. J. J. Hesling of Rothamsted Experimental Station, consisting of a 2-inch length of rubber tubing pushed on to the end of a 6-inch silver steel rod in the stirrer. The rubber tubing is slit up for about half its length to form six or eight tongues. The boiling tube may then be held in the hand, while stirring, without fear of breakage, as may happen with metal stirrers. After stirring, the machine is run at speed with the rubber tongues just above the water surface in order to spin off any adhering eggs. Finally, the mixture is topped up to a given volume, say 30 ml, and an aliquot sample transferred with a pipette to a McMaster slide (Fenwick 1951), where the eggs and/or larvae can be estimated. Empty egg shells and clouded eggs are disregarded. It is necessary to blow down the pipette for a few seconds before drawing off the sample because the eggs soon collect at the base of the tube.

Tests have been carried out using this technique with and without the use of the stirrer. Four field samples were used containing cysts of *Heterodera major* (O. Schmidt) Franklin, these being opened as described above and then mixed only by blowing into the water through the pipette. After counting, the sub-samples were washed out of the McMaster slide and returned to the boiling tube and again made up to a known volume. They were then mixed for one minute on the electric stirrer and the eggs re-estimated with the McMaster slide. The percentage of eggs lost in each of the four samples, taking a mean of the four counts on the McMaster slide, are shown below :

Sample	Estimated Eggs per Cyst: Blowing	Stirring	Percentage Lost
I	41	50	18
II	109	160	32
III	69	105	34
IV	129	180	28

Analysis shows a significant difference between the two estimates in each sample ($P = 0{\cdot}05$) with a mean over all samples of 37 ± 10 eggs per cyst lost by blowing alone. This is equivalent to a mean loss of 28 per cent, a figure rather higher than that obtained by Reid when using a roller as compared with a Hagedorn needle, and may indicate that the less efficient method of opening, necessarily used in the present technique, may be compensated by the use of the stirrer, which allows practically all of the eggs to be freed.

Sample I had apparently behaved rather differently from the others and, since this had the lowest egg-cyst ratio, another set of tests was carried out. In these, cysts from a large sample of *H. major* were opened and divided into four batches: those that were almost empty; those with about 20–100 eggs; those with about 100–200 eggs; and those with a considerable number of eggs in them. Each batch was made up in a separate beaker and the eggs per cyst estimated before and after mixing with the electric stirrer. The results are set out below:

Sample	Estimated Eggs per Cyst: Blowing	Stirring	Percentage Lost
A	19	53	65
B	62	112	44
C	201	318	37
D	245	356	31

In this set the mean loss was 44 per cent, and when the figures were analysed by angular transformation it was found that there was a significant difference ($P = 0{\cdot}05$) between the different samples. Moreover, the loss was much greater when the cysts were relatively empty, and it was found that there is a significant correlation between the loss and cyst contents. Since in most field samples a large proportion of the cysts are found to contain few eggs, it is very important to use an efficient method of breaking up the clumps of eggs which otherwise tend to adhere to the cyst wall and are lost when taking an aliquot sample.

The writer is indebted to Mr. B. Church of Rothamsted Experimental Station for assistance in the analysis of the experimental results.

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THE RED-GALL *SAPPAPHIS* SPECIES ON APPLE

by H. L. G. STROYAN

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The Apple-gall aphid, *Sappaphis devecta* (Walker), and its unusual biology are well known to advisory entomologists working in large fruit-growing areas. But it is not well known that a second, closely allied species causes similar galls on the leaves of apple trees in the spring. This latter species, *Sappaphis anthrisci* (Börner), is so close to *S. devecta* morphologically that to identify an individual specimen is not practicable even for a specialist. Samples of ten to twenty specimens can be placed with rather more confidence in one species or the other. The biology of *S. anthrisci*, however, is so widely different from that of *S. devecta* that the two species can readily be separated by field observation once the facts are known.

S. devecta remains in its scarlet or rosy pseudogalls throughout the summer months, forming its sexuales at some time between the end of June and the end of July. The second generation consists, in very large measure, of apterous intermediates which are more or less heavily pigmented on the abdominal dorsum like the alatae and may have a rudimentary, or even a nearly complete, pterothorax. With these are a certain number of normal apterae and a very few alatae—probably less than one per cent of the total numbers.

The initial gall formation of *S. anthrisci* is identical with that of *S. devecta*, but here the resemblance ends. The second generation consists almost entirely of alatae which migrate to the leaf bases of the hedge parsley, *Anthriscus sylvestris* Hoffm. Mixed with these may be a very small number of apterae and intermediates, the latter of a different type from those of *S. devecta*, with short wing rudiments but no marked abdominal pigmentation or pterothorax. The galls of *S. anthrisci* are abandoned by mid-June.

Galls examined during the immaturity of the second generation may be identified by the type of nymph contained in them. Those of *S. anthrisci* will show developing wing-buds in about 95 per cent of the third and fourth instar individuals, while those of *S. devecta* will appear to be normal, immature apterae in more than 95 per cent.

It follows from the biology of *S. anthrisci* that it does not necessarily infest the same trees from year to year. The return migration in autumn will naturally be spread over a fairly wide area. It also follows that local concentrations of *S. anthrisci*, such as result in "*devecta*-trees", do not usually occur. Galls scattered widely but thinly over an orchard may indicate either species, but heavy local concentrations will normally indicate *S. devecta*.

S. anthrisci is a rather common species in eastern England, and is probably widespread wherever apple and *Anthriscus sylvestris* occur together. The exules on *Anthriscus* are very like those of *S. crataegi* (Kltb.) on carrot, but have long, acute antennal and body hairs.

Börner has recorded three other *Sappaphis* species as causing red galls on apples. Of these, which all occur in Britain, *S. choerophylli* (Börner), migrating to *Choerophyllum temulum* L., has been found rarely near Cambridge, but not yet on apple; *S. brancoi* (Börner), migrating to *Valeriana officinalis* L., is only known as an endemic subspecies from the Keswick area; and *S. radicola* (Mordv.), which is widely distributed on *Rumex* roots, has not so far been shown to have any gall-forming generations on apple in this country.

AN OBSERVATION ON LOOSE EAR OF WHEAT

by R. Eric Taylor and Elizabeth R. Schofield

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From time to time records are made of Loose Ear in wheat (Moore, W. C. and Moore, F. Joan, *Bull. Minist. Agric. Fish. Lond.*, No. 129, 1950, 40). Isolated ears and the stems bearing them become bleached before maturity (Plate I, *top left*), and the stem is found to be severed within the sheath just above the top node and the ear is readily withdrawn. Although the cause is not known, it is of interest to record observations made in 1954 on stages leading up to the severance of the stem.

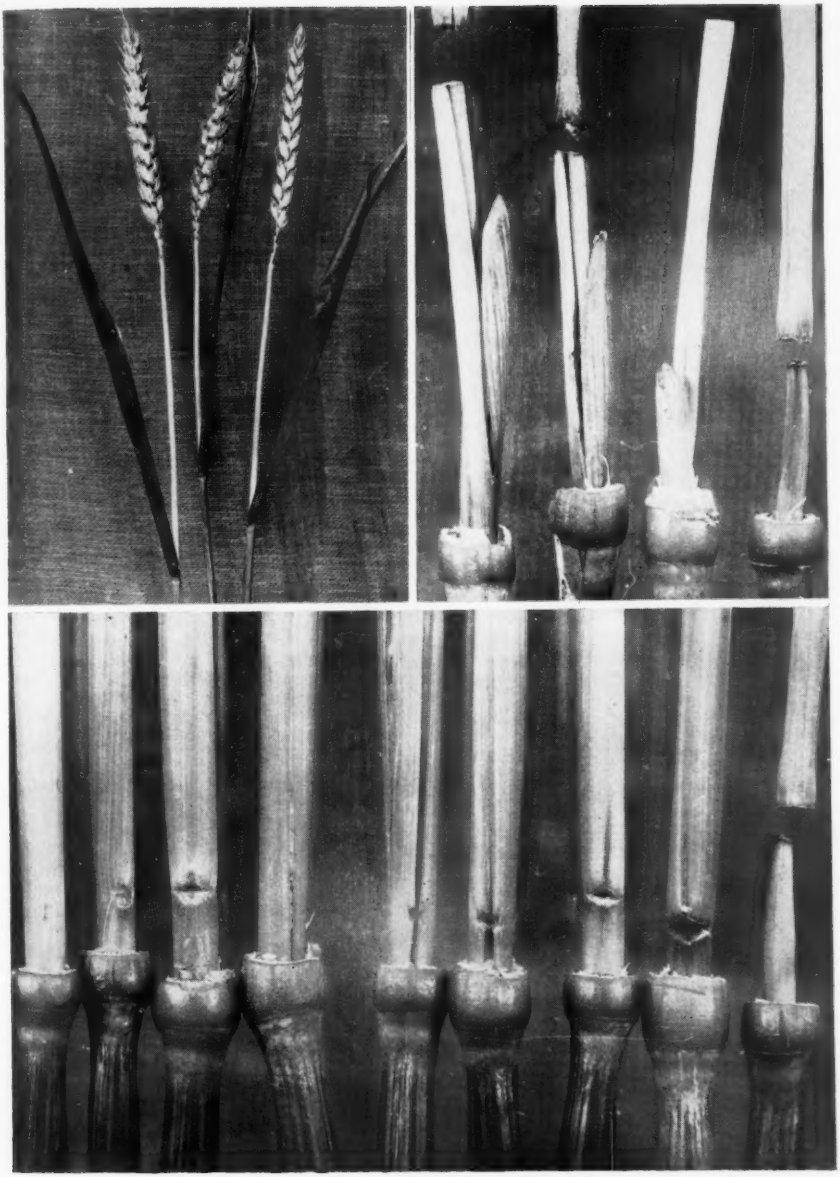
A high proportion of loose ears was observed during July 1954 at Napton, Warwickshire, in a crop of Hybrid 46 sown in October 1953 following a four-year ley. The condition, affecting one or more tillers per plant, could be found scattered throughout the crop, but more especially in a low-lying corner of the field. The crop, as a whole, was still green and on the point of flowering, and the bleached loose ears were most conspicuous. In a large number of plants examined no correlation with any form of foot rot could be found, neither was there observed any indication that the severance of the stem was due directly to insect attack. Cattle, however, had earlier strayed into the field.

A symptom consistently accompanying the Loose Ear condition was a lengthwise groove extending down one side of the stem from the base of the ear to the point of severance. The regularity with which this occurred led to a detailed examination of a large number of tillers with seemingly normal ears but with grooved stems, and a comparison with normal ears on stems that were not grooved. Careful dissection of the stems from the sheaths showed that the groove in the stem was associated with progressive stages in the fracture of the stem at a point from $\frac{1}{4}$ to $1\frac{1}{2}$ inches above the top node (Plate I, *bottom*). Following complete fracture of the stem, axillary shoots developed within the sheath from the top node (Plate I, *top right*).

We thank Mr. F. J. Bennison for bringing the case to our notice and Mr. K. J. Coghill for examining the material for insect attack.

INTERNATIONAL PLANT PROTECTION CONGRESS, 1957

The 4th International Plant Protection Congress will be held at Hamburg in Germany on September 8–15, 1957. Those who wish to receive particulars should send their names and exact addresses, as soon as possible, to the Biologische Bundesanstalt für Land-und Forstwirtschaft, Braunschweig, Messeweg 11–12, Germany.



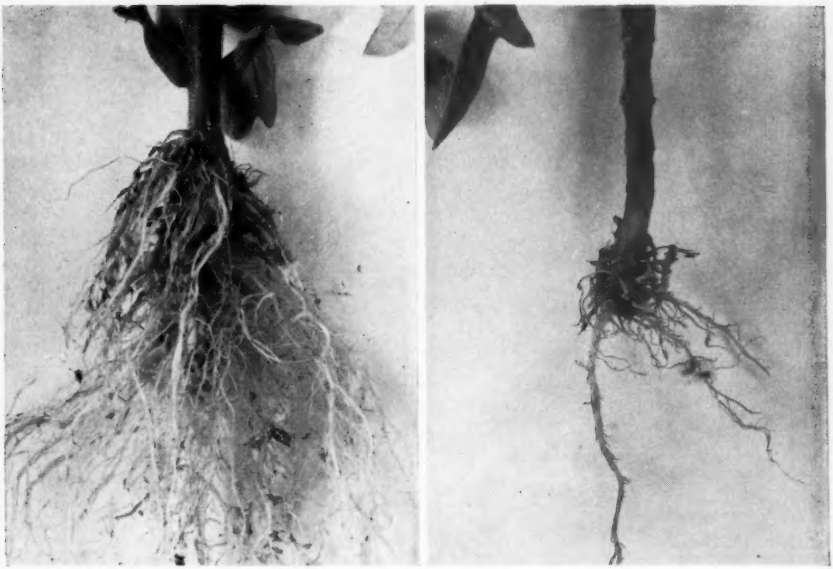
Top left : Bleached ears at flowering time following severance of peduncle just above last node of stem.

Bottom : Stages in the fracture of peduncle (flag leaf removed).

Top right : Development of axillary shoots from last node after fracture.
Hybrid 46. July 20, 1954.

PLATE I

DAMAGE TO TOMATO ROOTS BY BHC (see p. 105)

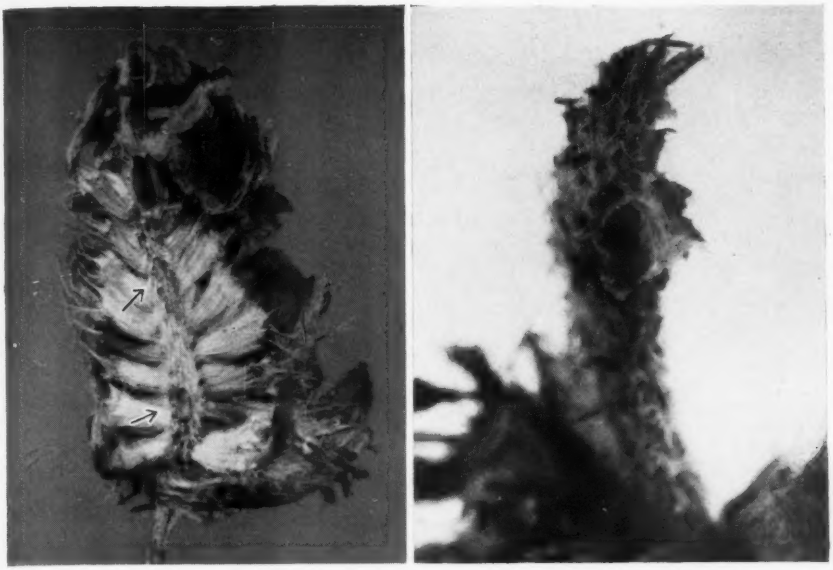


1. Roots of tomato plants, var. Stonor's Moneymaker. *Right* : a fortnight after watering with 0·04 per cent BHC. *Left* : untreated at the same time. Roots treated with 0·0125 per cent *gamma*-BHC showed only slight damage.

CABBAGE ROOT FLY DAMAGING GROWING POINTS OF STOCKS (see p. 114)

2. Mining and disruption of growing points of Brompton stock with larvae of *Erioischia brassicae* *in situ*.

CLOVER SEED WEEVIL DAMAGE (*see pp. 99–105*)



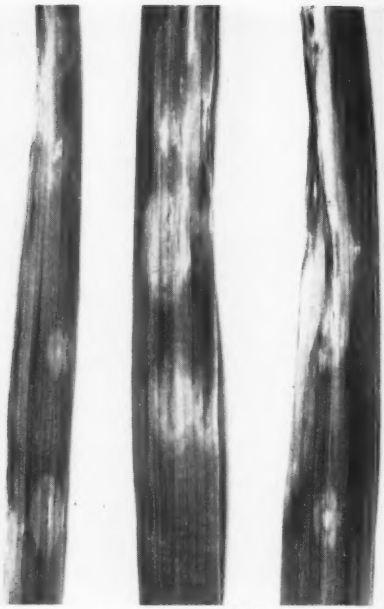
1. Clover flower-head showing (*left*) concave feeding areas on the axis in which *Apion* larvae were found embedded; and (*right*) the partially stripped axis with the cavity from which an *Apion* pupa was removed.

CONTROL OF BLACK CURRANT LEAF SPOT (*see pp. 97–8*)

2. Bushes which had received two sprays with oil-Bordeaux photographed in late September. Unsprayed bushes (in rear) were completely defoliated.

PLATE III

HALO BLIGHT OF OATS

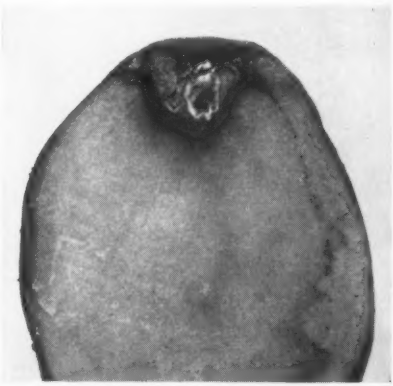


Photos. : Welsh Plant Breeding Station.

1. Panicles showing glume infection (*left*) and severe damage to spikelets (*right*).

2. Typical "halo" symptoms on flag leaves. (*Variety* : Milford)

STEM END HARD ROT OF POTATO (see *p. 114*)



3. Lesion at heel-end of tuber. (*Variety* : Home Guard)

4. Section showing rot separated from healthy tissue by well-developed callus layer.

HALO BLIGHT OF OATS

by D. J. GRIFFITHS AND W. T. H. PEREGRINE

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The first authentic occurrence of Halo Blight, *Pseudomonas coronafaciens* (Elliott) Stapp, on oats in Great Britain, was reported in Scotland by Dr. Mary Noble (1949). This disease is one of the few bacterial diseases of oats, and until now it has not been considered sufficiently serious to warrant a great deal of attention. In 1954, the disease was found for the first time in the Welsh Plant Breeding Station trial and breeding grounds, occurring on a small sprinkling of oat breeding material (Davies *et al.*, 1955). By 1955, its incidence on the plots had intensified, and, for this reason, various observations were made on some of the more severely infected selections and varieties. A detailed survey was also carried out on a 6-acre field of spring-sown commercial oats, to determine the degree of infection, and to ascertain what loss of yield could be attributed to Halo Blight infection.

Characteristic Halo Blight symptoms were observed in early June on the upper leaves of the oat plants, approximately three weeks before the commencement of panicle exsertion. The first typical indication of the disease was the appearance of light green spots on the leaf sheaths and laminas, which represented centres of primary infection. As infection proceeded the spots gradually enlarged, and in time the central portion had a brownish spot and eventually died. Outside this a light green halo appeared, and this became yellow with age to give the disease its characteristic symptoms (Plate IV, 2). In many instances these halos elongated and coalesced to give the leaf a striped appearance, finally resulting in its death.

One hundred samples were taken from the field which was approximately square and was arbitrarily divided into ten rectangular areas of equal widths. Ten readings were taken at regular intervals along each section. All the plants within a frame one yard square were counted, and this was followed by a count of plants showing symptoms of the disease, special note being taken of those with severe head infection. The results clearly indicated a uniform distribution of the disease throughout the whole crop, the average proportion of infected plants and those manifesting symptoms of damage to the panicles being as follows :

Mean percentage of plants infected	$3{\cdot}93 \pm 0{\cdot}064$
Mean percentage of plants with infected heads	$1{\cdot}85 \pm 0{\cdot}057$

Rather more precise data on the nature of the damage to panicle development and grain maturation were obtained from the experimental plots and head-row selections. Infection of the panicles in which the disease was observed on the leaves in the early stages varied from 15·4 to 37·1 per cent. From these, twenty infected heads were selected, and counts were made of the spikelets which showed signs of infection, and also of " blasted " spikelets, to assess what proportion of the panicles had been damaged. The results were as follows :

Mean number of spikelets per panicle	93 (*Range* 50 to 163)
Percentage of spikelets with affected glumes	96·5 (83 to 100)
Percentage of spikelets sterile	40·7 (3 to 88)

Thus in heavily infected plants the effect on grain development could be very considerable. In at least 50 per cent of the panicles examined, the number of fully developed seeds set had been reduced to less than half of the potential

number, and the overall mean percentage reduction in seeds set for all infected panicles was 40·7. This would represent a loss of the order of 4·0 per cent in yield of grain in a crop showing a 10 per cent panicle infection.

GENERAL OBSERVATIONS

Although the summer of 1955 was very dry, and, according to earlier observers, not conducive to the spread of the disease, considerable infection occurred in the field under observation, and in other experimental plots at the Station. Contrary to the observations of Elliott (1920), the infection did not decrease with the advance of the dry weather during the summer, and a number of small, young lesions were observed to form throughout the period the crop remained green, indicating that the disease was still active.

Kingsolver (1944) found in inoculation tests under greenhouse conditions that the behaviour of the disease most symptomatic of the typical field reaction occurred at 70°F. At 50°F disease injury was separated into two categories, with the leaf symptoms only agreeing with the field reaction. Comparing our 1955 field observations with those of Kingsolver, it appears questionable whether the spread of the disease is effectively retarded by high temperatures.

One interesting feature of the advance of the disease among plant populations was the occurrence of badly infected plants, whose panicles upon emergence had become a sticky mass. In the close vicinity of these panicles a number of plants occurred showing typical lesions on the glumes only, with no sign of stem or leaf infection. It seems probable that the inflorescences of these latter plants had been infected by the bacteria disseminated from the badly diseased plants, as the panicles at this stage appeared to be unusually attractive to insects. This may well have been a contributory factor in the dissemination of the bacteria, in addition to wind and rain. The markedly higher incidence of secondary infections in the immediate proximity of those panicles whose spikelets were prevented from expanding by the bacterial slime is considered to be of significance in relation to spread in the field.

Damage to the ear and grain was observed to be particularly severe in all instances where Halo Blight symptoms were apparent on leaf sheaths enclosing the unexserted panicles. Typical panicles formed by plants infected in this manner are shown in Plate IV, 1.

No effective method has yet been evolved to control this disease, although Elliott (1920) reported that partial control could be obtained by immersing the grain in 0·3 per cent formaldehyde solution. Moore and Moore (1950) also reported that steeping or sprinkling the grain with formaldehyde as for the control of wheat Bunt is partially effective, and that under experimental conditions warm-water treatment of the seed at 134·5°F for 10 minutes has given complete control. The lack of complete control by a fungicide such as formalin suggests that some of the bacteria may be found within the pales. A satisfactory control on an economic commercial scale by seed treatment would thus prove difficult, but more information on this is required.

As far as we are aware, nothing is known of varietal responses to the disease in Britain, but observations indicate that varieties with compact heads appear decidedly more liable to damage of their panicles than those possessing a more open type of inflorescence. In America, Kingsolver (1944) reported that selections derived from crosses involving Bond as one parent have proved to be highly resistant. Thus if seed treatment proves difficult, the development of resistant varieties will have to be considered as an alternative method of control.

If the increase in the incidence of the disease proceeds at the rate which we observed in the 1954–55 seasons, its appearance must be viewed with some concern, and further study of varietal reactions is well justified.

We thank Dr. F. Joan Moore of the Plant Pathology Laboratory, Harpenden, for her help in confirming that all the various pathological symptoms on the samples of oat leaves we sent to her were attributable to Halo Blight.

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CONTROL OF BLACK CURRANT LEAF SPOT BY SPRAYING WITH OIL-BORDEAUX MIXTURE

by H. H. GLASSCOCK AND W. S. ENGLISH

National Agricultural Advisory Service, Wye, Kent

In 1950, a pilot trial was made on a nursery in East Sussex to test the relative efficiency of three fungicides: a proprietary liquid copper preparation, glioxalidine, and a summer white-oil Bordeaux, for the control of Black Currant Leaf Spot, *Pseudopeziza ribis*, Kleb. In this trial, bushes sprayed with the oil-Bordeaux after picking retained their leaves several weeks longer than the unsprayed bushes, or the bushes sprayed with the other fungicides.

In early July 1951, the same three fungicides, and also ferbam, were applied to black currant bushes on another nursery in East Sussex, and again the bushes sprayed with the oil-Bordeaux retained their leaves after those on the bushes on other plots had fallen.

Following the results of this work, plot trials were begun in 1952 to test the cumulative effect of applying oil-Bordeaux to black currant bushes over three successive years. The bushes chosen for the trials were of the variety Westwick Choice, which had been planted in 1949. Bushes of this and other varieties on the selected holding had been severely affected by Leaf Spot in previous years.

To prepare 100 gallons of the oil-Bordeaux mixture, 7½ lb of hydrated lime was first stirred in 80 gallons of water, and to this suspension was added, while stirring, 13½ pints of summer white-oil emulsion previously thinned with 15 gallons of water. Lastly, a concentrated solution of copper sulphate, made by dissolving 5 lb of granular copper sulphate in 5 gallons of water, was stirred in. The mixture was applied as soon as possible after preparation. (Certainly it should not be used more than 24 hours after mixing).

Three treatments were compared with unsprayed controls: that is, oil-Bordeaux applied once only immediately after flowering; once only immediately after picking; and twice only, immediately after both flowering and picking. The trial was arranged in four adjacent blocks, each treatment being applied to a row of four bushes within each block. The treated rows were separated from each other by an unsprayed guard row. Application (to run off) was made with a knapsack sprayer.

The order of leaf-retention in relation to time of spraying application was the same in each of the three years. Towards the end of September the twice-sprayed bushes retained almost the whole of their foliage (Plate III, 2), while those sprayed once after picking retained about half their leaves. Defoliation was complete on both the unsprayed controls, and on the bushes sprayed once only after flowering, but these latter retained their leaves longer than the unsprayed. In 1954, the ripe fruit of each recorded bush was weighed. The results may be summarized as follows:

Treatment	Leaf Retention in Late September (Each Year)	Mean Yield of Fruit from 4 bushes (1954)
		oz
Sprayed after flowering	No leaves retained ..	46·6
Sprayed after picking	Half the leaves retained ..	46·5
Sprayed after flowering and after picking	Nearly all leaves retained ..	82·6
Unsprayed	No leaves retained ..	24·0
		S.E. ± 6·9

The differences in yield indicated that a single application of oil-Bordeaux either after flowering or after picking nearly doubled the yield, and that there was a further substantial increase when the application was given at both stages. Size and quality of fruit from bushes receiving application before and after flowering were very markedly superior to those of fruit from bushes of the other treatments. The fruit from bushes sprayed once, after flowering or after picking, were also of better quality than those from unsprayed bushes.

The results indicate that in plantations where Leaf Spot is severe, oil-Bordeaux applied immediately after flowering and immediately after picking may be expected to give complete control of the disease and to result in a marked increase in weight and quality of fruit. Fruit from bushes sprayed with copper preparations is, however, usually rejected for processing when the maximum content of vitamin C is to be preserved. A single annual application of oil-Bordeaux immediately after the fruit is picked would be expected to control moderate infections and might leave insufficient copper residues to prejudice acceptance of the following year's crop by the processors.

Acknowledgment is made to Mr. R. C. Seeley of Wye College for advice on the mixing of oil-Bordeaux; to Mr. G. M. Jolly of East Malling Research Station for statistical analysis of the yield figures, and to the grower who gave facilities on his holding for the trials to be undertaken.

CLOVER SEED WEEVIL DAMAGE IN EAST ANGLIA

by T. J. LEGOWSKI

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Striking yield increases after controlling Clover Seed weevils (*Apion* spp.) with DDT have been noted overseas (Beloselskaya, 1950 ; Schenker, 1951 ; Janezic, 1953). In England and Wales, although DDT treatment has become a routine on many farms, there is little experimental evidence about its value, particularly with regard to yield of seed. A preliminary investigation was therefore carried out in 1952 on red clover crops in Hertfordshire, extended to broad red clover in Cambridgeshire in 1953, and throughout the Eastern Counties in 1954. The practical implications of the results have already been discussed elsewhere (Legowski, 1955a).

Possible migration of weevils between small experimental plots within commercial seed crops presented a problem which was overcome by using whole- or part-fields as experimental units. Weevil density was estimated by sweeping with a 12-inch net ; 20 consecutive sweeps were made whilst walking the crop, this routine being replicated two to five times, depending on the size of the field and the time available at each visit.

As the adults, or at least a proportion of them, migrate into fields, it was thought that the distribution of weevils might not be uniform throughout a field : an attempt was therefore made to ascertain this. Preliminary observations were made on a rectangular 28-acre field of broad red clover bounded by ditches and hedges on two opposite sides. Sweeps were made on August 3 along five lines parallel to, and at three different distances from the hedges. On September 9, four samples of 250 flower-heads each were collected for larval counts, two about 20 feet from the edge and two from the middle of the field, about 450 feet from the hedges. An average of 26·5 weevils were taken in a replicated series of 20 sweeps about 20 feet from the hedges ; an average of 22·5 per 20 sweeps about 100 feet from the hedges ; and 15 per 20 sweeps in the middle of the field, about 450 feet from the hedgerows. Two samples, each of 250 flower-heads, taken about 20 feet from the hedges, gave 74 and 85 weevil larvae respectively, but two similar samples taken in the middle of the field gave only 42 and 61 larvae.

These figures show that there was a slight, though significant ($P<0{\cdot}05$), decrease in the numbers of weevils away from the edges of the field, and this agrees with observations made by Morgan Jones (1950) on late-flowering clover. However, when sweeps and samples were taken from another and smaller field (about 15 acres) no such difference emerged. These results were confirmed by subsequent observations on several fields and it was concluded that, except on the larger fields, by the time the buds have appeared after the first cut the weevils are fairly evenly distributed over the field. Also, when a sample of flower-heads from an untreated field was examined to assess the distribution of larvae within the heads, this was found to be approximately Poisson.

Larval density was estimated from samples of flowering heads. In 1952, the flowers in two random square foot quadrats per field were picked and bagged separately for examination in the laboratory. After drying in a greenhouse these samples were boiled and floated in paraffin (Morgan Jones, *loc. cit.*), after which the weevil larvae were decanted off on to a filter paper in a Buchner funnel and counted under a binocular microscope.

Because it was often difficult to determine which plants or flower-bearing stems were inside and outside the one foot square quadrats, especially when lodging had occurred, the sampling method was changed in 1953. Instead, 25 heads were picked at random at each of ten sampling stations along two diagonal traverses in each field, the heads from each traverse being bagged separately and examined as in the previous year. There was close agreement between the results for each traverse within fields, and, in 1954, the samples were taken from one traverse only.

The method used for extracting the larvae was not checked for accuracy in 1952 or 1953, but a single check was carried out in 1954. Ten random lots of ten flower-heads each were taken from one sample of 250 heads, examined under the binocular microscope and the weevils counted ; the remaining 150 heads were treated by the usual flotation method. The first method gave 73 weevils and 54 Hymenopterous cocoons from which Braconids, *Triaspis floricola*, Wesm. emerged later. These were almost certainly parasitizing the *Apion* larvae, (Legowski, 1955b). Ninety weevils were recovered by the second method. Therefore, if each cocoon represented one parasitized *Apion* larva it is clear that a figure obtained by the flotation method gave a serious underestimate of the larval density. As there is evidence that parasites were present on all fields and that, on average, 40 per cent of *Apion* larvae were attacked, it is probable that the larval counts in 1954 were underestimated by about the same amount. A similar figure might also apply to 1953.

Final yields of clean seed were obtained from the farmers in 1952 and 1953. In addition, one or more samples of flower-heads were taken from each field just before harvest. These consisted of 30 mature heads from each of ten random sampling stations within each field. After drying, the heads were stripped of remaining leaves and stalks and the samples were weighed. They were then rubbed and hulled by hand and the clean seed weighed. In 1954, owing to the abnormally wet season, only a few fields were harvested, some of them only in part, and yields were assessed entirely by sampling.

FIELD EXPERIMENTS, 1952–54

In 1952, observations were made on thirteen fields of broad and late-flowering red clover in Hertfordshire. Six of the fields were sprayed once with DDT at 5–6 pints of 17 per cent emulsion in 20 gallons of water, or 2½ pints of 25 per cent emulsion in 40 gallons of water per acre ; seven were unsprayed. Of the treated fields, two were sprayed three weeks after the first cut, three about five weeks after cutting, and the late-flowering clover was sprayed once in May and again three weeks later. Sweep net estimates of weevil density were made in July and flower-head samples were taken on ten fields for larval estimates at the same time. Head samples for yield comparisons were taken from eight fields in the third week of August. The results are summarized in Table 1.

In 1953, nine fields of broad red clover on one farm in Cambridgeshire, all with similar cropping histories and fertilizer treatment, provided an opportunity for more detailed work in an ecologically uniform area. Three of the fields were sprayed once with 3½ pints of 25 per cent DDT emulsion in 25 gallons of water per acre at the end of June, about two weeks after the first cut ; three were sprayed twice with the same concentration of DDT, once at the end of June and a second time towards the middle of July ; and three fields were left as untreated controls. Weevil assessments were made by sweeping six of the fields in the middle of May (about six weeks before the sprays were applied), and subsequently all the fields at various times during the remainder of the season.

Clover Seed Weevil

Table 1

Results from Preliminary Observations on Thirteen Fields in 1952

	Type of Clover					
	Dorset Marl		Late-flowering Red		Broad Red	
	Untreated	*Treated*	*Untreated*	*Treated*	*Untreated*	*Treated*
Number of fields	1	—	3	1	3	5
Mean no. adult weevils per 20 sweeps	10	—	13	1	9	1
Mean no. larvae per flower-head	2·5	—	2·1	—	1·2	0·6
Mean yield (cwt per acre) ..	0·8	—	1·3	4·0	1·9	3·7
Mean weight of seed in 300 heads (grammes)	—	—	15	—	19	36

Larval counts were made from flower-head samples collected in the middle of August, and estimates of seed yield were obtained from head samples taken in the first week of September. Yields from eight of the fields were obtained from the farmer; the ninth field was not harvested owing to wet weather. The results are summarized in Table 2.

Table 2

Results from Observations on Nine Fields on One Farm, 1953

	Three Fields Unsprayed	Three Fields Sprayed Once	Three Fields Sprayed Twice
Mean no. of adults caught in 20 sweeps :			
May 11	6	8	7
July 8	52	10	12
July 29	54	17	4
Aug. 11	45	11	4
Mean no. of larvae and pupae per flower-head :			
Aug. 13	2·2	0·4	0·1
Mean yield of clean seed (cwt/acre) ..	0·7	1·6	1·7
Mean air-dry weight of samples of 300 heads, September 7 (grammes)	46·5	67·3	70·5
Mean weight of seed in samples of 300 heads (grammes)	8·8	26·7	28·2
Mean weight of heads, less weight of seed (grammes)	37·7	40·6	42·3

In 1954, observations were carried out on twenty-one fields of broad red clover scattered throughout the Eastern Counties. The experimental fields were sprayed so that half of a given field, or, in some cases, a strip at least 40 feet wide, was left untreated as a control area. On one field, two opposite corners of approximately one acre each were compared with two untreated acre plots in the opposing corners. Complete results were obtained for 16 such paired units, and additional results were available from 4 fields, 2 of which were not sprayed at all, and 2 of which were sprayed completely. Treatment in all cases consisted of a single DDT spray of approximately 1 lb of insecticide in 25–40 gallons of water per acre applied about two weeks after the first cut for hay or silage. Sweeping for weevils was carried out on all fields at least once after treatment; flower-head samples for larval counts were taken at the beginning of September and for yield assessment at the end of that month. Owing to the exceptionally wet season, only three fields were harvested commercially and the results have therefore been examined on the basis of the head sample data. Since replicated samples were taken for each treatment from several fields, it was possible to estimate the variation between treatments within and between fields. The results are summarized in Table 3, in four groups according to the numbers of adult weevils caught in 20 sweeps.

TABLE 3

RESULTS FROM OBSERVATIONS ON TWENTY-ONE FIELDS IN THE EASTERN COUNTIES, 1954

No. of Fields	Range of *Apion* Densities per 20 Sweeps: (1–10) 3		(12–18) 4		(22–33) 6		(44–87) 8		Mean, All Fields	
	C	T	C	T	C	T	C	T	C	T
Mean no. of *Apion* per 20 sweeps	6	1	14	1	29	2	59	1	31	1
Mean no. of larvae and pupae per flower-head	0·08	0·03	0·4	0·04	0·3	0·05	0·4*	0·04†	0·3	0·04
Mean air-dry weight of 300 heads (grammes)	80·8	85·8	65·3	74·3	69·9*	81·6*	69·1	77·8	70·5	78·9
Mean weight of seed from 300 heads (grammes)	43·3	45·0	29·8	36·5	29·3	37·6	29·2	38·7	31·7	38·9
Weight of heads less weight of seed	37·6	38·8	35·7	37·7	39·8	42·4	39·9	39·3	38·4	39·6

C = Control ; T = Treated field ; *, Four fields ; † Five fields.
The means include the results from two completely sprayed and two unsprayed fields.

DISCUSSION

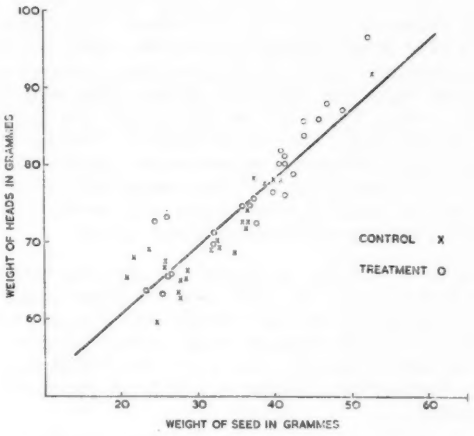
The results show that DDT has given a good control of adult weevils and a substantial reduction in the numbers of larvae infesting flower-heads. In 1953, a single spray reduced the numbers of adults by about 75 per cent and of larvae by 80 per cent, and two sprays at an interval of 2–3 weeks reduced the numbers by 90 and 95 per cent respectively. In 1952 and 1954, a single spray application reduced adults and larvae by about 90 per cent, although one field in 1952 was found to have a surprisingly large number of larvae, possibly because the spray application had been delayed until five weeks after hay-cut and was almost certainly applied after oviposition had taken place.

In 1952, there was a yield difference of approximately 2 cwt of seed per acre between sprayed and unsprayed fields. In the following year the difference of 1 cwt of seed per acre was significant at the 1 per cent level, though the difference of 0·1 cwt between fields receiving one and two sprays respectively was not significant. Proportionally, rather greater real differences appeared between weight of seed in the harvest head samples from the treated and untreated fields. In 1954, when yields were assessed entirely by sampling, the average seed yield from 300 heads was 38·2 grammes on the treated and 32·6 grammes on the untreated portions of fields. The standard error of each of these means is 0·8, that of a single observation being 1·80, so that the average yield increase of 17 per cent is again highly significant. In this year there was some evidence that fields responded differently to treatment, though it is not known whether this was a genuine ecological effect.

One of the difficulties in work of this kind is to obtain an accurate assessment of yield. The relation between the potential yield or the amount of seed actually present in the field, and the farmer's yield is an unknown variable. The total quantity of seed from a field is comparatively small, so that losses likely to occur in various stages of harvesting and cleaning may be considerable and may, as was shown by Hanson and Harrison (1950), amount to as much as 60 per cent of the total possible yield.

Although the farmer's yield may often reflect the effect of the treatment, it may not necessarily be the most reliable measure, especially where the effect is not very pronounced. More accurate results would probably be obtained by careful harvesting of a series of small areas at random within a field. Where a comparison of the potential yields is required and where labour and time

available are limited, a method based on sampling flower-heads appears to offer an acceptable alternative. Since the results for 1952 and 1953 included the seed from head samples as well as the farmer's yields, it was possible to compare them. The mean correlation coefficient for both years was 0·86, which is significant at a probability of 0·01.



Regression of total weight of 300 flower-heads on weight of seed.
$b = 0{\cdot}89 \pm 0{\cdot}06$

The results in 1953 have shown that there was a relationship between dry weight of flower-heads and the weight of seed, and the results obtained in 1954 confirmed this (*see* figure). The correlation coefficient of weight of flower-heads on weight of seed was 0·91 with 49 degrees of freedom. This relationship is sufficiently good for flower-head weight to be used instead of seed weight in investigations where quick and approximate comparison of the results is wanted. Spraying appears to have slightly, but significantly ($p = 0{\cdot}05$), increased the weight of heads, excluding the seed. This increase amounted to about 10 per cent in 1953, and in 1954 to about 4 per cent. There was a marked visual difference in 1953, between the bulk of the samples from treated and untreated fields.

By counting the number of seeds in a series of 1 gramme samples in 1953 and 1954 and by taking the weight of seed from 300 flower-heads collected from those fields, it was possible to compute approximately the average number of seeds per flower-head. The figures were : 26, 65 and 75 on the controls and fields sprayed once and twice respectively in 1953, and 67 and 78 on the untreated and treated areas in 1954. This would indicate an average loss of 44 seeds per flower-head on the controls in 1953 and 11 seeds per flower-head in 1954. Comparing these figures with the number of larvae recovered, and assuming that the whole of this loss was due to *Apion*, it would appear that in 1953 one larva destroyed 18 seeds, and, in 1954, after adjusting the 1954 larval figures to allow for the error introduced by parasitism, about 15 seeds. Unfortunately, it is impossible to adjust the 1953 figures, as no observations on parasitism were made in that year. Comparing the 1954 figure alone with the often repeated statement that one *Apion* larva can destroy 5–10 ovules (Jenkins,

1929 ; Balachowsky and Mesnil, 1935 ; Morgan Jones, 1950 ; Janezic, 1953), it is clear either that one larva can destroy more than 5–10 seeds, or that other pests were partly responsible for the loss of seed. Both these explanations may be correct.

The damage caused by the larvae is not necessarily always restricted to the ovules. Schenker (*loc. cit.*) has pointed out that stunting and wilting of flower-heads may follow an attack in the early stages of the flower development. Also, in 1953 and 1954, it was not unusual to find on the axis of the flower-heads concave feeding areas of varying depth, sometimes cutting right through the fleshy axis between the florets (Plate III, 1) and often with the *Apion* larvae partly embedded inside. There can be little doubt that this type of damage would interfere with the flower and seed development and that indirectly it could account for quite a high proportion of the losses. Again, other pests, such as aphids, clover midges, *Sitona* spp. and *Phytonomus* spp., were present in most fields and, although no detailed observations were made, it was clear that in several cases DDT gave a partial control of the aphids.

There was also some evidence to suggest that spraying reduced the numbers of midges in the flower-heads. In 1954, after the flower-heads were examined for *Apion* larvae, samples from five treated and five untreated areas were submerged in brine and the floating midge larvae counted. The numbers recovered from the untreated areas were in all cases higher than those from the treated ones, the average for a sample of 250 heads being 350 on the former and 140 on the latter.

SUMMARY

The effects of DDT on *Apion* adults and larvae and on the yield were investigated on six treated and seven untreated fields of red clover in Hertfordshire in 1952 ; on six treated and three untreated fields, all on one farm in Cambridgeshire, in 1953 ; and on 17 Eastern Counties fields which were treated, in part, in 1954. DDT applied about two weeks after the first cut gave 80–90 per cent kill of adults and a similar reduction of larvae in the flower-heads. Slightly better control was obtained with two sprays. Yield of seed was about twice as high on the treated as on the untreated fields in 1952 and 1953 ; in 1954, when yields were assessed entirely by the sampling of flower-heads, there was an average increase of 17 per cent following treatment. Spraying also appears to have increased slightly the weight of the flower-heads, excluding the seed.

There was a good correlation between the dry weight of 300 flower-heads and of the extracted seed.

Cocoons of *Triaspis floricola*, Wesm., thought to be parasitizing *Apion* larvae, were found in the flower-heads from the nine fields sampled in 1954.

I am indebted to Dr. H. C. Gough, who suggested this work, for help and encouragement, and to Mr. J. G. Rowell of the A.R.C. Statistical Group, Cambridge, for help with the statistical analyses. Grateful thanks are due to the many farmers and district officers in East Anglia who co-operated in the work, and to Mr. E. Dant for the photographs.

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DAMAGE TO TOMATO ROOTS BY BHC

by H. J. GOULD

National Agricultural Advisory Service, Wye, Kent

A grower in Kent lost some 20,000 young tomato plants in May 1955 following a watering treatment with BHC against wireworms. The plants were falling over, the stems apparently breaking off at a constricted region at soil level, and in some plants there were short vertical cracks in the stem at or just below soil level.

As a diagnostic test, I potted up some 8 inch Potentate, and 3–4 inch Stonor's Moneymaker plants and, after establishment, watered some of each of them to soil saturation with a proprietary BHC emulsion at about 0·04 per cent BHC and others with a proprietary *gamma*-BHC emulsion at 0·0125 per cent *gamma*-BHC.

A fortnight later, the Stonor's Moneymaker were lifted. Those which received a BHC treatment were stunted and had reduced root systems compared with the controls, and the stems at and below soil level were constricted and marked by vertical cracks (Plate II, 1). Those treated with *gamma*-BHC were indistinguishable in growth from the controls but had slightly reduced root systems, rootlets being absent from about an inch of the stem from soil level. The Potentate plants, which were larger and harder in growth when treated, showed similar, but less marked, root symptoms.

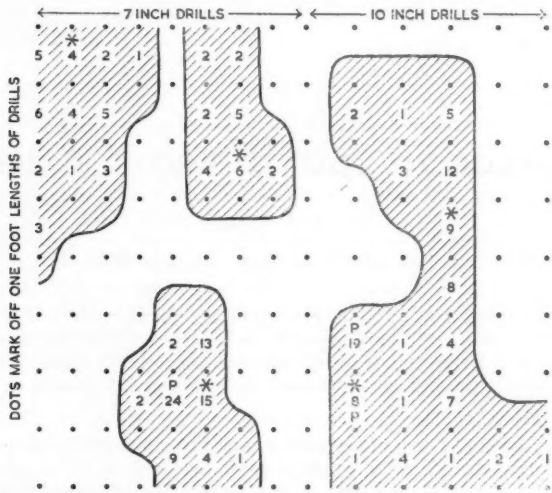
SPREAD OF TAKE-ALL FROM INFECTED WHEAT PLANTS

by VALERIE M. WEHRLE AND L. OGILVIE

National Agricultural Advisory Service, Bristol

It has been found that the spread of Take-all, *Ophiobolus graminis* (Sacc.) Sacc., through the soil, occurs during the growing season of the plants by root contact, and that the fungus grows most rapidly along the roots in alkaline and loose-textured soils (Garrett, S.D., *Ann. appl. Biol.*, 1936, **23**, 667–99). However, little information is available concerning the rate and distance of spread of the disease in the field.

In 1950, a season that proved favourable for the spread of Take-all in the South-West, a small experiment was carried out in a border of an old walled garden in Bristol. To ensure that the soil was initially free from the disease a large number of soil samples were collected at random from the site, mixed together, and placed in glass jars. Wheat seeds were sown in the jars. After three weeks the seedlings were washed out, and the roots were examined for Take-all infection. None was found. The pH of the soil was 7·9. Wheat, variety Holdfast, was then sown on the plot, on November 1, 1949, in 9 drills 7 inches apart and 5 drills 10 inches apart, all the drills being 8 feet long.



Spread of Take-all from infector plants (*) in a plot trial. The drills are shown divided into foot lengths, and the number of infected plants in each length is shown. P = perithecia produced.

On January 16, 1950, groups of three infector plants were introduced into the plot at each of the five randomized points shown in the diagram. These infectors were seedlings grown in soil collected in December from a field that had been very severely affected with Take-all in the previous summer. After three weeks growth in the infected soil their roots were washed out and examined. Seedlings with a minimum of two roots showing Take-all lesions were selected as the infectors.

In most of the infection experiments described in the literature, cultures of the fungus on cereal or similar media were spread along the rows. This method is open to the objection that the inoculum may be blown or washed about, or may be transported by cultural operations. We therefore used infected wheat seedlings washed thoroughly from all adhering soil.

At the end of August, the straw of all the plants in the plot was cut off at about 12 inches above ground level. The plants were then lifted in foot runs from each drill, tied in bundles and stored. There were about 15 plants per foot run. At a later date the roots were washed free of soil and examined for the presence of Take-all lesions. Where these lesions were indistinct they were examined microscopically for the presence of runner hyphae. The number of infected plants in each foot run is shown on the diagram, from which it will be seen that there was considerable spread across as well as along the drills, with both the 7 inch and the 10 inch drill spacing. The greatest distance of spread was about 5 feet.

EFFECT OF POTASH ON THE INTERNAL BLACKENING OF POTATOES

by A. E. W. BOYD AND G. R. WHITE

Edinburgh and East of Scotland College of Agriculture

Blackening or bluish-black discoloration of parts of the flesh of potato tubers without any external symptoms frequently occurs after bruising, especially when the tubers have lost turgidity. Most damage from this cause occurs in this country late in the storage season, commonly as a result of riddling and generally after sprouting has begun (Boyd, 1951). Most of the investigations into this trouble have been carried out in Holland, where it has been concluded (Botjes, 1927, 1929 ; de Bruyn, 1929 ; Van der Waal, 1929) that potatoes grown on potassium-deficient soils are much more susceptible than normal tubers.

During the three seasons, 1952–54, opportunity was taken to examine tubers from manurial trials laid down for other purposes in East Lothian on soils of differing states of fertility. The trials in each season were of two levels of nitrogen (2½ and 5 cwt of sulphate of ammonia per acre) and three levels of potash (0, 1½ and 3 cwt of muriate of potash per acre) on 6 × 4 randomized blocks. Soil analyses were made for each field before the application of the fertilizers. The crops were dug by fork and stored in bags for one to three weeks before being graded on a power riddle and rebagged. Samples were then taken. As susceptibility to discoloration after bruising varies within the tuber and is normally greatest at the heel end, all the tubers examined were cut in slices from heel to rose end.

CONDITIONS OF TESTING

In 1952, the crop of Majestic at Wolfstar, Ormiston, was lifted on September 30. The tubers received a certain amount of handling in being transported to a store in early December, but as each sack received the same treatment bruising probably occurred to a similar extent in each case. Complaints of discoloration before cooking led to an examination of samples from the various treatments. The produce from the replicated plots with each treatment had been bulked, and about 20 ware tubers were taken from each for examination on December 12.

In 1953, the crop of Arran Banner at Birnieknowes, Oldhamstocks, was lifted on October 8. Six bulked samples of ware from the replicate plots of the different treatments were examined on November 27, but little discoloration was observed. Between 30 and 40 potatoes for each treatment were then dropped from a height of 2½ feet on to a wooden floor, as in previous experiments (Boyd 1951), and test tubers were examined after three weeks. Again there was very little sign of blackening. The tubers were then dropped once more and examined again after a further three weeks, on January 12.

In 1954, the crop of Craig's Royal at Tranent Mains, Tranent, was lifted on November 4. About 20 tubers were taken from the produce of each of the four plots of each treatment and stored in paper bags in the laboratory until December 31, by which time most of the tubers had begun to sprout. A number of tubers from each sample was then examined, but only in the potatoes from plots which had received 2½ and 5 cwt of sulphate of ammonia, without potash, was any discoloration observed. The proportions of tubers discoloured were respectively 44 and 66 per cent for these two treatments. The remainder of the tubers were then dropped from a height of 3 feet and examined again three days later. The results are given in the table below.

An assessment was made in 1953 and 1954, of the blackening of the cut surface in each tuber, the categories being "severe" (with $\frac{1}{4}$ or more of the surface discoloured), "moderate" (with between $\frac{1}{16}$ and $\frac{1}{4}$), and "slight" (with $\frac{1}{16}$ or less). A Discoloration Index was calculated by multiplying the number of tubers in each category by the average discoloration for the category (severe = $\frac{5}{8}$, moderate = $\frac{5}{32}$, slight = $\frac{1}{32}$) and then dividing by the total number of tubers examined.

DISCOLORATION OF TUBERS IN RELATION TO FERTILIZER TREATMENT

Sulphate of Ammonia	Muriate of Potash	Percentage of Tubers showing Discoloration after Bruising				Index for Degree of Discoloration	
cwt per acre	*cwt per acre*	1952	1953	1954		1953	1954
		Dec.	Jan.	Dec.	Jan.		
2½	0	44·4	83·3	44·1	92·5	14·1	14·5
5	0	57·9	80·6	65·8	97·1	9·5	18·7
2½	1½	35·0	72·2	0	78·8	10·8	6·9
5	1½	42·9	77·1	0	71·3	9·0	9·4
2½	3	15·0	63·6	0	68·0	5·4	6·7
5	3	25·0	23·5	—	70·9	1·5	7·8

The results in the different years cannot be compared, since the initial fertility of the soil, the potato variety, and the degree of bruising differed in each case. But in each year the discoloration was greatest where potash was omitted, and, at least in 1952, there was an increase of discoloration with an increase of nitrogen at both potash levels. This was in agreement with the findings of the several Dutch workers. According to Mulder (1949), low potassium content

induces a high content of free tyrosine in the plant and an increased liability of the cells to sustain injury. Blackening due to melanin formation occurs when the tyrosine is liberated from the damaged cells.

The potassium status of the soils, before the application of the fertilizers, was determined by the *Aspergillus niger* method (Smith and Simpson, 1952), and the K_2O indices in the following soil analyses for the three years represent 100 times the mycelial weight in grammes of this fungus growth that was supported by 2·5 grammes of the soil :

	pH	P_2O_5 p.p.m.	K_2O Index
1952	6·5	260	38
1953	7·1	180	46
1954	6·2	200	33

The initial potassium content of the soil in 1953 was higher than in the other years, and discoloration was produced only after repeated standard bruising in the laboratory. In 1952, discoloration was very marked in all treatments after normal riddling, without resort to artificial methods of bruising. In 1954, it occurred only in tubers from the plots where no potash had been applied. From the present results it is not possible to determine the critical level of potassium for susceptibility, but the indications are that potatoes grown in soils in the lower moderate or low (K_2O Index below 35) groups are more likely to become discoloured after bruising in normal farm practice.

Previous experiments (Boyd, 1951) were carried out in early spring and summer when sprouting had started, and little discoloration was observed before that season. Discoloration in the present experiments was obvious fairly early in storage in December and January. The experiments thus confirm, in this country, the importance of an adequate available potassium supply to minimize the effect of bruising potato tubers, although other factors such as the condition of the tuber and the severity and site of the bruise are also involved.

Thanks are due to Mr. K. Simpson, Soils Analyst in this College, for much helpful information.

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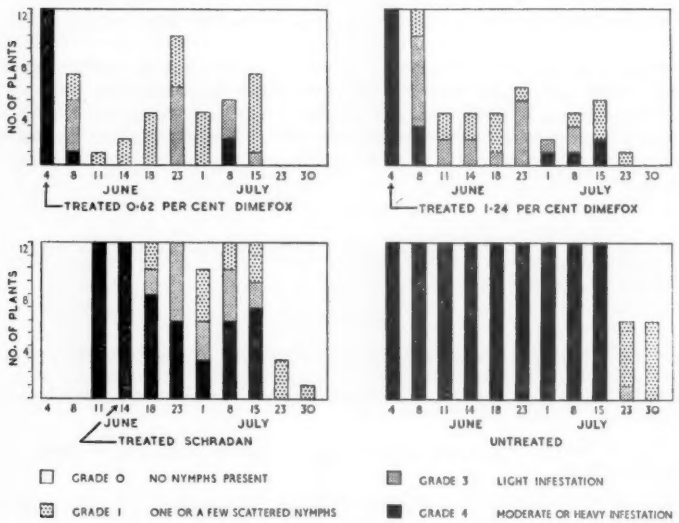
CONTROL OF THE HOP-DAMSON APHID WITH DIMEFOX

by P. W. CARDEN

National Agricultural Advisory Service, Cambridge

A new method of controlling the Hop-Damson aphid, *Phorodon humuli* (Schrank), on hops, was described by G. A. Emery (*World Crops*, 1954, **6**, 289–92). This is to apply with a ladle a small quantity of the systemic insecticide dimefox to the crown of the hop plants early in June. The treatment is stated also to control Red Spider mite, and it has an advantage over other methods in that it eliminates the danger of spray drift.

An experiment was carried out at East Harling, Norfolk, in 1954, to test this method on nursery hops—where the spread of virus diseases by small numbers of aphids may be important. Three randomized blocks of three plots, each of four plants, were used for the comparison of 0·62 and 1·24 per cent dimefox with an untreated control. The treatments were applied on June 4, 1954, using 4 fl. oz per plant in each case. The hops outside the experimental area were sprayed with 12 oz of 66 per cent schradan per 100 gallons, at 150 gallons per acre on June 12, and at 200 gallons per acre on August 15, 1954.



Effect of treatments on nymph infestation of hop bine.

The infestation of alatae, adult apterae and nymphs was assessed on one bine of each plant once or twice a week, using Emery's system of grading. Comparative observations were made on the schradan-treated plants. The effect of the treatments was shown best by the number of nymphs on the plants, as the number of alatae was partly determined by the number of aphids migrating, and adult apterae did not appear in any numbers until some time after the treatments were applied.

The figure shows that on the untreated plots the numbers of nymphs built up steadily in June and then declined rapidly in mid-July. Both rates of application of dimefox reduced the numbers of nymphs to a very low level within a week of treatment, and they did not increase again. There was no appreciable difference in effect between the two rates of application. The reduction caused by two applications of schradan was less than that brought about by dimefox. The numbers of alatae rose for a short time on the untreated plots and then declined steadily. On all the treated plots the numbers fell gradually until mid-July, when all the remaining alatae had disappeared.

Thanks are due to Mr. G. A. Emery for providing the materials for this trial.

FURTHER EXPERIMENTS IN TURNIP GALL WEEVIL CONTROL

by T. ROSBOROUGH

College of Technology, Belfast, N. Ireland

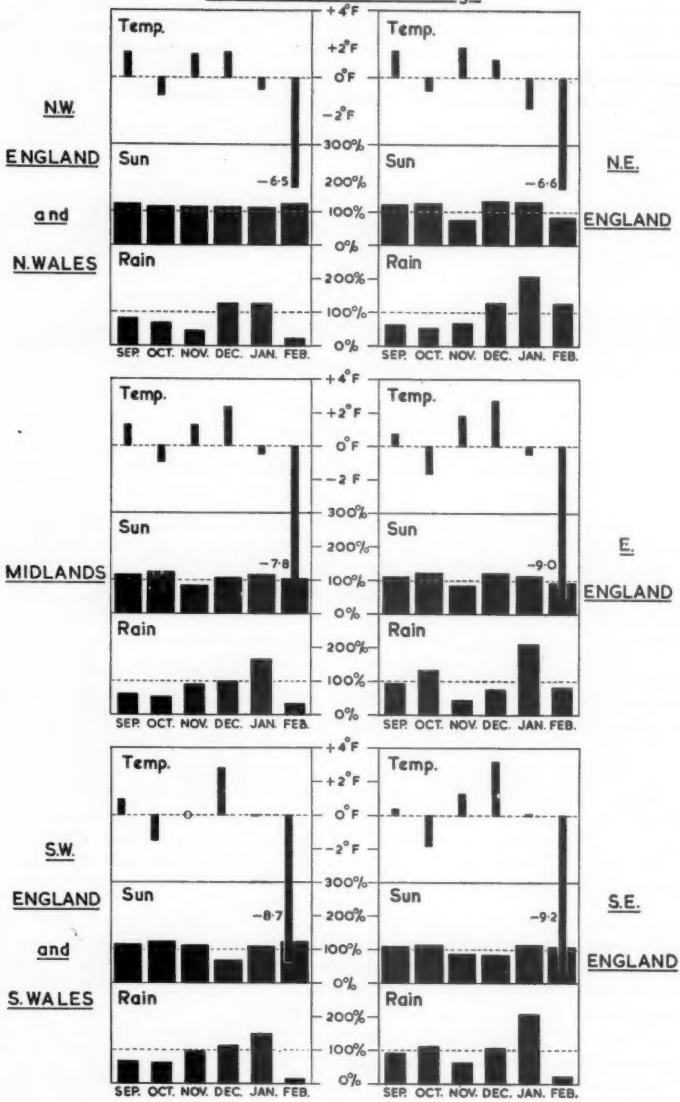
Effective control of *Ceuthorhynchus pleurostigma* Marsh on cabbage can be obtained with BHC (*Plant Pathology*, 1953, **2**, 123–5). During 1953, I tested some other modern insecticides in similar trials at Cirencester. Insecticides were applied round the bases of the stems of cabbage plants at 1 lb per 160 plants, three days after transplanting. Treatments were replicated three times on plots of 45 plants arranged as a randomized block.

In one trial, planted out on June 15, a 2 per cent technical BHC dust reduced the proportion of attacked plants from 63 to 18 per cent, compared with a 28 per cent attack on plots treated with a 1·5 per cent dieldrin dust. In both cases the reduction was significant at a probability of 0·05, the difference between chemicals being insignificant. In a second trial, in which 59 per cent of the plants on the untreated plots were attacked, BHC 2 per cent dust reduced the attack to 5·6 per cent, dieldrin 1·5 per cent dust to 4·4 per cent, dieldrin 5·0 per cent dust to zero, and aldrin 1·5 per cent dust to 8·9 per cent. Again, there was little difference in the efficiency of the compounds tested, all of which reduced damage significantly.

Two seedbed trials were also carried out. Cabbage seed was sown late in July and insecticides were applied with a hand duster as a band about two inches wide along the seedling row at the second to third rough leaf stage. When the plants were large enough to transplant, a number from each plot were examined and any showing galls were recorded as attacked. Plants from the control plots in the two trials showed 22·5 and 26·7 per cent attack respectively, compared with 2·5 and 6·7 per cent on plants treated with a 1·5 per cent aldrin dust and 2·5 and 3·3 per cent on plants dusted with 1·5 per cent dieldrin. Treatments again differed significantly from controls, though not from each other. Clearly, aldrin and dieldrin dusts show some promise in the control of gall weevil.

SEPTEMBER–FEBRUARY WEATHER 1955–56

Variations from average



THE WEATHER OF ENGLAND AND WALES*

AUTUMN AND WINTER, 1955–56

Following the warm, dry, sunny months of July and August, September, as is often the case, was warm and sunny. Rainfall was generally below average, especially in the north-east and south-west, but there were unusually heavy thunderstorms on the 22nd. In October, the rainfall was still below average in the south-west and in the north. It was sunnier than normal almost everywhere ; temperatures, however, were low, except during the second week. There were some periods of dense fog from the 8th to the 13th, and later in the month snow- or sleet-showers were experienced. The first general autumn frost occurred on the morning of October 16. November was mainly mild, with dull conditions generally, apart from the west ; rainfall was low, absolute drought being recorded in parts of Essex and east Sussex.

December continued the mild weather, especially in the south ; the rainfall was slightly above normal, except in East Anglia, and heavy falls occurred in the northern hills. Much snow fell in north-east England between the 17th and 20th, lying to a depth of 1 foot in Yorkshire on the 20th. January was a wet month, but had a good deal of sunshine ; parts of southern and eastern England had twice their normal rainfall. Temperatures during the month were near normal. The true winter began on the afternoon of January 31, when exceptionally cold air over Europe surged slowly westwards bringing maximum temperatures below freezing point. This drop in temperature was accompanied by penetrating winds. The bitter, easterly weather persisted for almost all the month, producing the second coldest February of the century. Snowfall was fairly general but fell mostly on the east coastal areas ; totals were generally low in terms of inches of water.

The weather for each of the six months, September to February, inclusive, is represented graphically on page 112. Figures for the six districts of England and Wales are shown in terms of the deviation from the average of air temperature, sunshine and rainfall. The negative temperature deviations for February are outstanding ; the general dryness of the autumn and winter seasons is also evident.

* These notes, and the diagram on page 112, are provided by the Agricultural Branch of the Meteorological Office, and published by permission of the Director.

NEW OR UNCOMMON PLANT DISEASES AND PESTS

Stem End Hard Rot of Potato. During the harvest of 1947, potato tubers of the variety Home Guard were received from Lincolnshire showing a heel-end necrosis akin to Jelly End Rot, but firmer and more sharply defined. (Plate IV, 3). On cutting an affected tuber, the diseased area was seen to be very sharply defined, and separated from the healthy tissue by a well-developed callus layer (Plate IV, 4). Pycnidia were visible sparsely scattered over the necrotic area, and on examination were found to correspond closely with the description of those of *Phomopsis tuberivora* Güssow and Foster (*Canad. J. Res.*, 1932, **6**, 253–4), reported to be responsible for Stem End Hard Rot of potatoes in Canada by Foster and Macleod (*Canad. J. Res.*, 1932, **7**, 520–3). The disease had not then been previously recorded in this country.

Isolations from affected tubers readily and regularly yielded cultures of *P. tuberivora*, the identity of the fungus being confirmed by Professor C. G. C. Chesters of Nottingham University. Attempts to reproduce the symptoms on tubers of the variety Home Guard, by inoculating at the heel end with plugs of agar culture by the cork-borer technique, and storing in boxes lined with damp peat, failed during the winter of 1947–48. Further samples were received in 1949, which again consistently yielded cultures of *P. tuberivora*. Inoculation of 100 tubers followed by storage at different temperatures failed to reproduce the disease, which was not recorded again until 1955, when it occurred sporadically in a number of samples, mainly of King Edward, received for examination.

The fact that the symptoms have been seen only in the seasons 1947, 1949 and 1955, taken together with the failure to reproduce them by inoculation, suggests that *P. tuberivora* may be a secondary organism invading the depleted heel-end of the tuber consequent on the hot, dry weather of these three seasons. This view is supported by the distribution of affected tubers (variety Red King) in an irrigation trial on the N.A.A.S. Experimental Husbandry Farm at Gleadthorpe, Nottinghamshire. Affected tubers were found in 8 out of 12 samples drawn from the unirrigated plots, and they were absent from the 12 samples drawn from those irrigated.

E. LESTER

Cabbage Root Fly damaging Growing Points of Stocks. The larvae of *Erioischia brassicae* (Bouché) are rarely found attacking plants above ground, though Mrs. Miles (*Ann. appl. Biol.*, 1950, **37**, 260–7), has recorded this type of damage on various hosts. Specimens of Brompton stock infested with third instar larvae of *E. brassicae* were submitted by Mr. W. J. Moyse, Isles of Scilly, in September 1955. The terminal growing point was mined severely, causing disruption and death of the shoot and surrounding leaves (Plate II, 2, for which I am indebted to Mr. H. C. Woodville). Biological disbudding of the terminal shoot to encourage side shoots was effected in about half of the plants grown. Mrs. Miles found (*Ann. appl. Biol.*, 1951, **38**, 425–32), that oviposition on the aerial parts of the host is encouraged when the critical factors of direct sunlight and drought have been removed. In spite of the warm dry summer of 1955, the stocks were well sheltered by windbreaks of *Pittosporum* and *Escallonia* and were growing near a low-lying area with naturally impeded drainage. It is assumed that local atmospheric conditions were suitable for aerial oviposition, root attack in the granite-sand soil being negligible.

P. R. THOMAS

(4571) Wt. 46 K.9 9/56 Hw.